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ABSTRACT

Most countries participating in the Organisation for Economic Co-operation and Development are faced with rapid economic and socio-cultural changes and growing demands for education and training. Postsecondary education faces the challenge of providing high-quality education for all adults who need it in a cost-effective manner. One of the most promising ways seems to be to develop self-directed learning at a distance. The status of distance education versus face-to-face education is changing rapidly for five important reasons: (1) the cost of self-instruction will be lower than that of comparable face-to-face courses over the long run; (2) although open and flexible learning institutions are gaining acceptance, distance learning has been seen as peripheral and of lower status than traditional education creating obstacles for the mobility of students between modes; (3) distance learning institutions have pioneered pedagogical innovations and forms of cooperation by teams of university teachers to design interdisciplinary courses; (4) good distance learning programs afford better student-teacher interaction than traditional lectures; and (5) technology is breaking down barriers of distance allowing students involved in the same course to communicate and form a virtual classroom. Technology is not only transforming distance education, but also conventional face-to-face education, by providing students with new possibilities for self-instruction. The introduction of technology in both distance and face-to-face education is a complex process that will be influenced by the combination of factors like ethos and culture. Contains 29 references. (KP)

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A CLARIFYING REPORT

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Note by the Secretariat

1. In accordance with the agreed Programme of Work for 1993 [CERI/CD(92)1], and further detailed planning [CERI/NTI(93)1] the Secretariat has undertaken a major study: "The Impact of Information and Communication Technologies on Post-Secondary Education". This study has covered both modes of delivery, the conventional face-to-face education and distance education, and the way they are affected by modern technologies. The increasing importance of distance post-secondary education in meeting new demands for learning and training explains why specific attention was put on this particular mode of delivery. The major objectives of the whole study were defined as follows:

- -- to identify and analyse innovative post-secondary distance education and open-learning projects which experiment with new communication systems, in order to establish which advances in technology are both user-friendly and cost-effective;

- -- to clarify the nexus of various factors (economic, organisational, social, psychological and cultural) that militate against more pervasive use of information and communication technologies;

- -- to analyse the overall contribution of distance education to the post-secondary sector, how it competes with, reinforces or overlaps with the role of those institutions offering traditional post-secondary education;

- -- to undertake an analysis of the anticipated major changes in educational technologies in the perspective of the year 2000, and their consequences for delivery and content of education;

2. The attached document is the result of the prospective facet of work undertaken so far. It focus on the future and the challenges that information and communication technologies soon will pose for post-secondary education. In producing the report, three groups worked separately, reflecting the three parts of the report, each with a chairman and supported by the CERI Secretariat. Their reports were completed during the first semester of 1994 by Stephen C. Ehrmann, United States; William L. Renwick, New Zealand; and Jacques Hebenstreit, France. Each of the three reports has its own style, and although they all focus on three different but complementary areas (quality of learning, institutional issues, and technological developments), there is at times some unavoidable overlapping. It should be noted that the views expressed in this report are those of the authors and the groups of experts.

3. The present report will serve as one of the background documents for the Conference on "Learning Beyond Schooling -- New Forms of Supply and New Demands" which will be held at the OECD on 14-16th December, 1994. This conference, as agreed by the Governing Board at its Spring 1993 session, will pull together the results from the three CERI studies on information technologies, lifelong learning and internationalisation.

4. The present report starts also to address some of the key issues like cost effectiveness of distance

education versus face-to-face education, self-directed learning assisted by technology, the new relationships between conventional face-to-face and distance education as well as the educational uses of the future information highways, that the Board at its spring meeting 1994 agreed should constitute the main thrust of work during 1995 and '96 in this study.

5. The Governing Board is invited to:

i) COMMENT on the attached report;

ii) ADVISE the Secretariat which of its principal messages should be particularly further addressed in CERI future work and referred to the Education Committee for consideration in its activities in tertiary education;

iii) AGREE to recommend that, after taking into account comments from the Governing Board and additional information issuing from the December conference, the report be derestricted and published under the responsibility of the Secretary-General.

Executive Summary

1. This report is based upon the contributions from three working groups within the CERI study on The Impact of Information and Communication Technologies on Post-secondary Education. The result of this work has been written up by Stephen C. Ehrmann (United States), William L. Renwick (New Zealand) and Jacques Hebenstreit (France). Together the three contributions form a challenging analysis of likely future developments in the use of information and communication technologies in education. In this respect particular emphasis is put on possible and real development of self-directed learning and distance learning.

2. Most OECD countries are today faced with rapid economic and socio-cultural changes and growing demands for education and training in the context of lifelong learning which are putting strong pressure on post-secondary education institutions. Increasingly, they must develop systems of mass post-secondary education and training, and spend much more in future than they have in the past on continuing or recurrent education, second-chance education, and on training within industry.

3. In this respect, post-secondary education faces a triple challenge: how to provide a high-quality education suitable for the 21st century, provide it for all adults who need it and provide it in a most cost-effective way. As a consequence of this challenge, all Member countries are planning increases in their post-secondary sectors, but it is unlikely that they can meet this challenge by only extending the conventional face-to-face and institutionally-based learning system.

4. The report argues that one of the most promising way seems to be to develop self-directed learning, in other words to develop learning at a distance for students who, by definition, are not in a face-to-face situation. This is not new. What is new is that the status of distance education versus face-to-face education is changing rapidly. There are many reasons for that and the report elaborates on five important reasons.

i) The first reason is purely economic. It is the hope of many governments that through economies of scale, unit costs of self-learning over the long run will be lower than for comparable face-to-face courses, and the large expansion of post-secondary education that all countries foresee will be achieved at less cost to taxpayers.

ii) The second reason is institutional. Distance learning has for long often been seen as peripheral to the traditional post-secondary education system. The "non-traditional" learner as well as the "non traditional" teacher often had a lower status compared to others. However the recent success of open and flexible learning institutions has somewhat changed this situation, although the recognition of qualifications obtained through open learning institutions is still in many cases not accepted by traditional face-to-face learning institutions. This therefore creates obstacles for the mobility of students from distance to face-to-face modes and vice versa.

iii) The third reason is pedagogical. Because of the diversity of the students, their constraints of time and place, distance learning institutions have sought to innovate in pedagogical terms, and often more than the conventional system. The essence of distance-learning courses is that they have been conceived, devised and produced to support self-instruction. Distance learning institutions have pioneered forms of co-operation by teams of university teachers to conceive, plan and write courses of study by using interdisciplinary approaches, placing subjects in new intellectual contexts and exploring them from new perspectives.

iv) The fourth concerns the quality of education. The *OECD Jobs Study* has stressed the need to improve the quality and relevance of education and training. Quality is often a function of interaction with a good teacher. Because of the increasing demands for education, it is becoming more and more difficult to ensure such good interactivity in the conventional face-to-face system. Furthermore, lecturing -- very often to large numbers -- remains a major non-interactive tool for teaching. But with good distance learning programmes, the possibility exists for students to interact effectively with a good learning programme and its associated tutoring arrangements.

v) The fifth reason is linked to technological advancements. Information and communication technologies are now increasingly breaking down barriers of distance. Through networks, each user/learner has access to various sources of information as well as specialised discussion forums on different subjects. In this way, students involved in the same course can communicate between themselves, share problems and solutions, and form a virtual classroom together while being in different places and at different times. This is already happening, although not yet on a critical mass level, but it represents something radically new in education.

5. These technologies are not only transforming distance education, but also the conventional face-to-face education by providing students with new possibilities of self-learning. They are increasingly blurring the frontier between these two modes of education. In a way they compete, but distance learning - particularly assisted by technologies -- seems to be more dynamic in many cases. This explains why a number of conventional -- but innovative -- higher education institutions are now adapting instructional materials based on the use of multimedia, originally prepared for use in distance education. So it is argued in the report that the border-lines between distance education and traditional face-to-face education will increasingly be blurred thanks in part to the penetration of new information technologies

6. It is therefore argued in the report that the whole post-secondary education system is being challenged by new requirements and technological developments, particularly as it has to respond to the growing demands for education and training. A major challenge for face-to-face higher education institutions is now to transform its internal culture, bearing in mind that students entering post-secondary education have grown up with computers and multi-media learning packages in ways that, so far, many of their teachers in post-secondary institutions have not. Furthermore, face-to-face education will also increasingly be in competition with others sectors. For example, private sector enterprises are normally 24 October 1994 developing in-house education and training programmes that can be of very high quality. But this report ends by a warning that the introduction of information technology in face-to-face and distance education is a complex process that will be highly influenced by the combination of factors like ethos and "culture" in the sector of higher education; arguments about costs, and not least, initiatives taken by the private sector and Government.

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I. RESPONDING TO THE TRIPLE CHALLENGE FACING POST-SECONDARY EDUCATION: ACCESSIBILITY, QUALITY, COSTS

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Introduction

1. Institutions of post-secondary education, and those who pay for them, face three daunting challenges, each of which makes the other two more difficult to resolve:

- -- accessibility, especially how to reach and educate the full range of adults who deserve a chance at an education, despite their location, schedules, cultural differences or physical disabilities;

- -- quality, especially learning for the 21st century: how to improve the life chances of each of their adult learners, as individuals and as members of economic, cultural and political communities; and

- -- costs, especially the costs of achieving the first two objectives in the face of slow economic growth and other urgent social needs.

2. This triple challenge is forcing government officials and academic leaders to face troubling questions such as these:

- -- Can high-quality courses of study be offered at reasonable costs for large numbers of adults if one adds a few "innovative" programmes to otherwise unchanged institutions, perhaps while eliminating or expanding a few existing programmes?

- -- If the answer to the above question is "no" and it is necessary to take a deeper and more searching look at the assumptions that govern today's systems of post-secondary education, are there lessons that the best campuses can teach distance and open learning programmes? Are there lessons that the best open and distance learning programmes can teach campuses? Will it be necessary to leave traditional definitions such as "campus," "distance" and "open learning" behind and restructure post-secondary education?

3. If not met, this triple challenge will lead to a gradual deterioration institutionally and nationally. Those institutions that do not respond may find it harder and harder to find support for even their most central functions. Those countries that do not respond may find it more and more difficult to educate their citizens and maintain a vital national economy and life. And a world where too many countries fail in their educational responsibilities will become an increasingly dangerous place. In short, those who fail to respond have much to lose, and those who respond creatively and successfully have much to gain.

4. This report[1] is written for those leaders who face choices about whether and how to restructure post-secondary education in their countries. It describes a few concepts and examples that may help make sense of a seeming chaos of problems and possibilities.

5. The first section of this report takes a closer look at the triple challenge. Later sections lay the foundation for considering what types of arrangements for teaching and learning might be most helpful in meeting the triple challenge and what sorts of infrastructure are necessary to support those arrangements. The second and third reports in this volume, by William Renwick and Jacques Hebenstreit, will examine more closely issues of institutional structure and new information technology.

Section 1: The Triple Challenge

Challenge 1: Full and equitable access

6. In many countries, the pool of potential learners has grown faster than education budgets. There are many barriers to access:

- -- More of the adults who need post-secondary learning have different schedules from traditional teaching institutions and from one another due to family and work responsibilities.
- -- They may be distant from a campus offering the academic programme they need and may live in rural areas where there is no post-secondary institution at all.
- -- They may not be fluent speakers of the national language of the country where they are living.
- -- Their learning style may not be a good match for the particular type of education offered them. For example, they may be offered only an opportunity to study at a distance from campus, alone, when they need more contact with other learners. They may need visual materials in a course of study that relies mainly on text.
- -- Many are physically challenged in ways that, in previous years, would have led to a wasting of their talents; that is no longer a tenable position and, in some countries, it is no longer legal.
- -- A number have had poor experiences in earlier schooling and are thus intimidated by the forms of post-secondary education.

7. In the United States, for example, where the pool of 18-year-olds shrank during the 1980s, there is now a "New Majority" of undergraduate learners who are not going directly from high school through a full-time post-secondary education to a two- or four-year degree (Pew, Higher Education Research Program, 1990). The same thing is true in many other countries. Still, more adults are unable to enroll at all due to such barriers.

8. Terms such as "non-traditional learner" tend to blame the victim, assuming that there is nothing that post-secondary education can due for these marginal learners. However, the problem is not simply one of disadvantage (a label that points the finger of responsibility and blame at the learner and the learner's home community), but of accessibility. Imagine a school with doorways 1.3 meters high. It would soon have two populations of students: normal students and head-injured (non-traditional) students, otherwise (privately) called "weeds". Some faculty would believe in providing each weed with a raft of compensatory

medical and educational services, while other instructors would argue that this special treatment would be unfair to normal students (those who coincidentally were less than 1.3 meters tall). Both groups might take awhile to notice that there is a third option: invest in raising the height of the doorways. Once done, and after the brain-damaged weeds graduate, there would be only one type of student: normal.

9. The "low doorway" of the traditional academic programme is the fact that students who can afford to come within the campus walls and study full time can get access to a better education than students who cannot. The next section of this report considers how that situation came to be and how it is changing.

Challenge 2: Educating adults for the 21st century

10. Today's and tomorrow's adult learners will spend their lives in the 21st century and will need somewhat different knowledge and skills to do so. The growth of on-line library systems gives a physical representation to the dizzying growth of accessible information. In developed countries, it is commonplace to remark that adults will have four or five careers in their lifetimes, sometimes because their previous job has disappeared. Among the skills likely to be of increased importance in the next century:

- The ability to frame problems when facing unfamiliar situations. Tomorrow's problems may be similar to yesterday's once they are well understood but they will present themselves in mysterious forms. Once a problem has been framed, it must then be solved. Increasingly often, both the framing and solving of problems will require the use of powerful information technologies. Framing and solving problems will sometimes be simpler, often more difficult than before.

- The ability to communicate, especially with people from other cultures. Cultural differences are increasingly salient, within as well as between countries. Yet without certain common values and shared insights, political and social life becomes impossible, and conflict and human waste on a grand scale result.

- The ability to work in, form and lead teams and coalitions, once again including people from cultures other than one's own. This vital skill has seldom been taught thoroughly in schools or universities, yet research indicates that it is already one of the most important capabilities in the workplace (Klemp, 1977; Boyatzis, 1982). As interdependence increases, collaboration, like communication, will become even more universally important.

- The ability to identify what needs to be learned, and then efficiently learn it. Modern information technology will often furnish the means for learning. And every educated person will need to spend a certain fraction of his or her life keeping up with changes in that technology.

In all these areas what is essential is what Entwhistle has called "deep learning": in deep learning the student actively relates what is being learned to previous knowledge and experience, searching for patterns and underlying principles while continually checking evidence and relating it to emerging conclusions. Deep learning is surprisingly difficult to foster; research indicates that even students who get excellent grades often fail to understand seemingly simple science ideas that are the heart of the material that they have supposedly mastered.

Challenge 3: Control of costs per graduate[2]

11. Economies are growing quite slowly. Meanwhile, the compelling demands of other sectors such as health care and support for the aged are growing swiftly, faster than the growth of economies or population. The result has been a bind for post-secondary education: the demands on it to help heal and fuel national economies have increased but funds available to meet those educational needs are quite limited. In most countries, the costs of educating a sufficient number of adults are seen as difficult or even impossible to meet and the costs are growing. Controlling costs by cutting access or by degrading the quality of education is no answer.

12. There is no easy way out of this bind, and this report will not recommend a technological panacea. In fact the need to invest a significant fraction of the postsecondary budget in technology means that computing, video and telecommunication can be seen as part of the problem. This report will suggest several ways of shaping that investment so that technology is also part of an effective response to the Triple Challenge.

Section 2: To Understand the Future, Look First to the Past

13. No one denies that the possibilities that new technology offers education are bewilderingly numerous, rapidly changing and sometimes difficult to understand (by the time many of us understand a new technology it may have already become obsolete!). In such circumstances, it helps first to look backward and consider what the essential elements of learning have always been. With a foundation in the history of education, one can then look to the future and pointed questions about the facets of learning that any new technology must be able to support. Thus the next section of this report briefly describes traditional *technologies* of education, i.e., the physical and organizational means by which education has been provided.

Section 3: A Moment in History: Challenging the Ideal of Campus-Bound Learning

14. In most countries people may look at campus buildings and say "There's the university". They may look at a lecturer, and say "There's education". Why do they think so? When did these perceptions begin?

The cave and the campus

15. It is said that the first user of educational technology was a cave dweller named Thok. Thok was a bit better than average in survival skills, so curious cave people would bring gifts of food and clothing to Thok's cave and then ask questions about how to survive. They would talk in small groups, much as Plato and his students would do so many years later in the grove of Academe.

16. Being a good teacher, Thok learned as much from these "students" as they did from their teacher. Year by year, the crowds of students at the mouth of Thok's cave grew. Their teacher, fed by their gifts and thus not leading the hazardous life of a hunter-gatherer, grew ever wiser but ever more elderly. Finally Thok's failing voice could no longer be heard by those at the edge of the crowd. Thok then had an idea of historic dimension, folding a banana leaf into the shape of what today would be called a megaphone. With the aid of this technology, many more distant learners could learn from Thok.

17. Nor was educational technology the only craft invented on that day. Some in the crowd doubted the value of megaphonology. To test the teaching power of banana leaves, one of the cave people began walking around with a leaf on his head. Learning nothing, this first of all evaluators concluded that megaphonology was of no educational value[1].

18. For a long time learning resources such as manuscripts and smart people were as scattered as caves. Since these human and material resources were scarce, fragile in a violent time, and, in their own way, costly, educators had the bright idea of collecting them in a protected environment. Caves in due course gave way to cloistered libraries and campuses. Campuses also made sense because books and scholars could only be used by a few students at a time and, of course, only if the students came to the same place where the book or scholar was. At that time, and for centuries thereafter, that was the only sensible way to organize an education. This sense of a small, protected oasis of human and material resources in the midst of an intellectual desert may have given rise to Dean Julius Caesar's famous comment, "All the world is divided into two parts, on-campus and off-campus".

19. The campus was not so very different from the cave: safe, intimate with limited admission. The campus was also, like Thok's banana leaf, a technology designed to increase access to education and also to improve the quality of that education. Comparable inventions have become prominent elements of modern education: the printed book and the lecture hall. All these technologies make it possible for a teacher to provide directed instruction for more people than he or she could meet in an intimate cave or seminar room. The printed book was a particularly important advance because it meant that the teacher's message could reach across hundreds of miles and years, transcending even the death of the teacher. For the student, it meant access to even more teachers and to primary source material, too. Some people tend to approach the challenge of educational productivity rather simple-mindedly in terms of staff-student ratios. But notice that the advent of the printed book cut staff-student ratios (by expanding the number of teachers each student could reach) while simultaneously increasing the staff-student ratio (by expanding the number of students each teacher could reach).

20. People no longer argue with one another about whether the best medium of education is conversation in a grove of trees or reading a printed book. But they do have disagreements about quality in education. Before this report can discuss options for restructuring education, it must first revisit some of the basic disagreements about the definition of "high quality" learning.

Definitions of quality in post-secondary education

21. Quality should ultimately be measured by studying who begins and completes a course of study (access), the success of graduates in making a life for themselves and their communities (quality), and the efficiency of their education in light of that success (cost-effectiveness).

22. Because such studies are difficult and the results not available until long after they have ceased to have practical value, however, educators and governments often turn to a more process-centred way of

gauging quality. There are at least three distinctly different ways of looking at the quality of the educational process.

Definition 1: ***Quality of education is defined by the quantity and quality of the institution's academic resources***

23. Thus, by definition, the institutions richest in resources provide the best education. Traditionally, the institution owns its resources and keeps them within its walls: its full-time faculty, the books on its shelves, its laboratory equipment and so on. The institutions with the richest endowments are, by this definition, the best institutions. This is a convenient way to measure quality since resources are available for inspection by all.

Definition 2: ***Quality is defined by selectivity (exclusion)***

24. Those institutions that bring the fewest students into contact with their resources are the best institutions. This definition springs in part from the fact that traditional technologies of education -- the libraries, the laboratories, the faculty themselves -- can be used by only a few people at a time. People using this definition sometimes also include the student body as a resource, assuming that a major value of the institution lies either in the intellectual stimulation of a bright student body or the social value of a well-connected one.

25. When only a few people can use any educational resource at one time, policy makers face a difficult choice. If they make institutions selective, a few students get a good education and no one else gets one at all. If they expand education, the result is mediocrity by this definition. Many countries choose both options and have a dual-track system, reserving the best of the resources for a few students and spreading the rest thinly among a large number of other students who are judged less deserving.

Definition 3: ***Quality is defined by the silent, critical, creative conversation within the learner's mind that is spurred and supported by the learning environment***

26. This is an extension of *Definition 1*. The value of the resources is determined not by their cost, however, but by the ways in which they stimulate reflection and learning. The technologies of education can be divided into four groups, each supporting a different type of *interaction* between the student and the academic programme[4].

- *Conversing* with faculty, students and distant experts *in real-time*. In campus-bound institutions, real-time conversation is supported by the technology of the campus itself, which assures that all the conversational partners can easily be brought together. Other traditional technologies supporting real-time conversation include seminar rooms, the instructor's office and informal gathering places.

- Exchanging ideas and materials with faculty, students and others over a period of hours and days *("time-delayed conversation")* usually through the exchange of homework. This exchange is also facilitated by the compact campus community.

- The single learner's interaction with textbooks, lectures, videotapes and other *directed instruction* about the content of the course: these materials and messages are typically "broadcast" , i.e., sent from one point to many students.

-- *Learning by doing*: by using tools and resources that are the same as, or similar to, those of the professional: the typewriter, the research library, the laboratory, the studio.

27. Now that these three contrasting definitions of quality have been clarified, the report can return to the issue of quality in open, distance learning and campus-based learning in recent decades.

The rise of distance learning

28. Thok's banana leaf, the lecture hall and the printed book made it important that students spend at least some of their study time away from their primary teachers, sometimes in the back row, sometimes in the library or in their rooms. That's "distance learning", a term ordinarily applied only to programmes in which the student has little or no contact with the instructor and ordinarily assumed to be inferior to "face-to-face learning". Yet, distance from a single master can create higher quality learning when that distance enables students to interact with more experts (some through the books they've written) and more peers and to spend more time in learning by doing. Such distance also frees the instructor to work with more students (increasing both accessibility and cost-effectiveness).

29. Distance learning became a significant enterprise with its own organisational identity when print duplication became less expensive and the demands for adult learning outstripped the ability of the society to build campuses. Unfortunately, these early forms of distance learning (called "correspondence learning" in some countries) could be usually classified as low quality by all three definitions:

-- *Definition 1:* the rich resources of the campus, such as the library, were usually not available to the distant learner.

-- *Definition 2:* correspondence was not usually exclusive -- quite the contrary, it was intended to include students who could not attain an education any other way.

-- *Definition 3:* of the four forms of interaction, correspondence emphasized only one: the student's thoughtful interaction with the instructional message (the print materials). The learner was relatively isolated from other people (real-time and time-delayed exchange), and there was little work in the laboratory, research library or studio (learning by doing).

Open learning

30. The term "open learning" is applied to a variety of related forms of learning and will not be described in detail here. Like "distance learning", the term is usually meant to offer a contrast to "traditional" campus-based programmes, denoting programmes that place certain fundamental choices in the hands of each learner. For example such programmes are less constrained in schedule, tempo, modes of assessment or location of study. In recent years, some open and some distance learning programmes have begun to look even more alike, with each providing adults with relatively self-contained bodies of learning resources through academic programmes that are organisationally separated from "normal" education.

31. In the 1970s and 1980s, some institutions and countries began to strengthen the quality of distance and open learning by investing in providing richer instructional resources (i.e., using *definition 1*). Sometimes this investment took the form of the creation of open universities that created and then offered well-structured courses to large numbers of students studying at a distance. In the United States, many

institutions were already serving the New Majority with on-campus and locally produced distance learning programmes. Progress was accelerated by a major private gift. Inspired by what he had seen of the Open University while Ambassador to Great Britain, Walter Annenberg made a grant of $84 million to the Corporation for Public Broadcasting to create the Annenberg/CPB Project. Aided by further funding, the Project was able to create packages of video and print materials costing as much as $7 million per course to develop. Their pedagogy was innovative. For example, packages teaching second languages relied on an inductive approach and helped students gain insight into a new culture by using engaging video-based stories produced in the countries under study. Annenberg/CPB Project science courses illuminate the history and applications of science, and display natural phenomena that occur on scales far beyond the scope of traditional laboratory demonstrations. In short, use of video made it possible to provide students with vivid, multi-faceted learning materials that were better than almost any campus could provide unaided. As a result, thousands of institutions in the United States and in approximately eighty other countries began using these course materials on campus, even at highly selective institutions, and for distant learners.

The ideal of campus-bound learning

32. Ever since the days of Thok, as technology's limitations forced education into the cave of the campus, educators have made a virtue of necessity, and made an ideal of campus-bound learning. The best university was presumed to be the one that owned the most and best resources (including faculty) and had the best students within its walls. What was outside its walls did not matter.

33. The success of the best open universities and of the Annenberg/CPB Project, not to mention technologies of resource sharing pioneered by printed books, interlibrary loan and time-shared computing, raise real questions about whether *Definition 2* (quality as exclusivity) and the ideal of campus-bound learning are still defensible. Modern video and print duplication, and video broadcast, made it possible for large numbers of learners to profit from the same instructional resources at the same time. But questions about quality could still be raised by *Definition 3* since the Annenberg materials and others like them emphasized directed instruction, not learning by doing, real-time conversation or time-delayed conversation.

34. Fortunately, the late 1980s and early 1990s were also a period in which new technologies also began to strengthen those other three facets of the learning process. The next section will examine how technology can improve both quality and accessibility in all four facets of the learning process.

Section 4: Using Today's Technology to Support High Quality Courses of Study and Student Services

35. The predictable improvement in digital technology (sometimes estimated to be an improvement of 20 per cent in price-performance per year) enables periodic, unpredictable and often surprising changes in the ways educators can support the four dimensions of interaction.

36. The sheer unexpectedness and excitement of new technology tends to draw all eyes to itself. It tends to focus discussion around the newest technology and the quest to discover what it can do best. For educators this is usually a mistake. *One cannot build cutting edge education on cutting edge technology.* Cutting edge technology is ordinarily too expensive (relative to its lesser price several years later), too brittle and too difficult to learn to use. That's the bad news.

37. The good news is that through extensive use in and outside education, the newest applications of computing, video and telecommunications become affordable, reliable, familiar (almost to the point of invisibility) and invaluable. Every year, more, better technologies become available for use as part of cutting edge education (some years after they are first used in other sectors).

38. Thus, it was that by 1990 changes in educational practice demonstrated concretely that a technological threshold had been reached and passed in at least some countries: educators could now enrich and extend each of the four dimensions of interaction.

Real-time conversation within a small group

39. Real-time conversation among students, between the student and the instructor, and between the student and an external expert is uniquely useful for coaching as the student develops new skills and for brainstorming. For those who doubt the importance of real-time conversation in learning, try the following experiment with a partner:

- Each of you take a paper and pencil and sit back to back so neither of you can see the other's paper.
- Your partner should draw a simple figure on a piece of paper, using no more than seven straight lines.
- Your partner should orally instruct you in how to draw the identical figure. You are NOT allowed to ask questions, nor to turn around to see your partner's drawing, nor can your partner look at your drawing. Time how long it takes you to draw the figure and grade yourself for accuracy once you are finished.
- Now sit face to face so that you can see one another's drawings, allow speaking and repeat the experiment. In which experiment did you learn more quickly and correctly how to draw your partner's figure? This is a simple and powerful demonstration of the difference between one-way instruction (directed instruction) and real-time interaction in a small group.

This simple exercise is complemented by a vast body of research on the instructional power of collaborative learning.

40. *Audio conferencing* is still the most flexible, least expensive way to support real-time interaction among people in different places. Any telephone provides a point of entry to the conversation. Students, faculty and "visiting" experts can usually participate from their homes, offices or nearby educational facilities.

41. *Audiographic conferencing* has been used in distance learning for some time in Canada, the United States and other countries. Using one or two telephone lines, an ISDN line, or a high-speed connection, widely separated faculty and students can talk while seeing the same text and graphics on their computer screens. The visual side of this technology is also sometimes called a "shared white board." In a calculus course, for example, anyone in the class can:

-- display an equation representing an action shown in a video image (both of which are displayed almost instantly on everyone's computers);

-- draw a graph representing the equation (which then also appears on each screen); and

-- ask a question about the image via audio hookup while pointing to that segment of the image (everyone sees a cursor move to that point on their screens).

42. There are different types of audiographic conferencing systems. Most allow the sharing of images. Some enable two or more people to work on a piece of software together. These systems can be used for tutoring, enabling the distant tutor to "reach over the student's shoulder", to demonstrate a programme feature or to modify the student's work, and for collaborative work on a shared project such as a spreadsheet, graphic image or piece of music.

43. *Real-time writing:* It is also possible to converse by computer alone if the participants type their conversation instead of speaking. Such arrangements are sometimes used in composition classes. As one student in such a course remarked, "After a while, I forgot I was writing". That's one purpose of this teaching: to provide a bridge between the unconscious ease of informal conversation and the new language of formal written conversation. Too many students see the written word as an exercise to satisfy a teacher; real-time writing helps break down that perception.

44. Northern Virginia Community College in the United States used real-time writing to create interaction among two relatively homogenous but very different groups of students on two of its campuses: one group lived in a rural area while the other lived near a military base. The instructor made use of the differences and friction between the two groups to create the energy for her composition class. (Bruce, Peyton and Batson, 1993).

Instructional Functions and Technologies

Technologies supporting student engagement in:	Older Technologies	Newer Technologies
Live Conversation Functions include coaching, brainstorming	Seminar room with. round table, blackboard Residential campus (make it easy to run into people)	Audio conferencing Audiographic conferencing 1-way live video with audio talkback; 2-way video "Chat" & other real time writing
Time-Delayed Conversation Function: reflective conversation and other exchanges requiring investment of time during the exchange	Residential campus (makes it easier to exchange homework) Mail, regular and express	Fax E-mail and computer conferencing Videotape (e.g. of student performance and faculty critique)
Learning by Doing Function is to learn the skills of a graduate by creatively practicing those skills, using the tools and resources similar to those to be used later	Typewriter Library (research material) Laboratory Studio Internship programme	Computer for designing, composing, simulating, and analyzing experimental results Use of authentic video from a foreign country to study that country's language, culture On-line use of distant libraries, computer-based research tools, and data
Directed instruction Functions include explaining and demonstrating.	Lecture hall Slide projector Textbook	Live and taped video Computer tutorial, drill

45. *Two-way video* is occasionally used for small group conversation, but it is rarely affordable for applications requiring large numbers of such conversations; one exception is when time is quite valuable, resolution of ambiguity is important, and the visual dimension is crucial. Certain medical applications fill this bill, for example, some of which have been tested as part of DELTA in Europe.

Time-delayed conversation within a small group

46. In traditional settings time-delayed conversation is carried out through the exchange of homework, a slow process at best. Homework exchange can seem impoverished because it typically is limited to three conversational turns:

-- the instructor poses a question (a task);

-- the student responds;

-- the instructor responds some time later with a grade. That usually ends the conversation, because grades can be conversation-stoppers, but also because, by the time the grade is received, the course has often gone on to new topics.

47. Using technologies such as electronic mail, time-delayed exchange can proceed in a rhythm of hours rather than days or weeks and, thus, can support a wider variety of instructional purposes, e.g., a more thoughtful, slower-paced form of brainstorming, role playing simulations, student communication about projects they are doing together. The learner can receive feedback when it is still meaningful.

48. While electronic mail and computer conferencing are still often restricted to the text medium, each year there are more systems operating on high-speed networks with a user-friendly capacity to send and receive any digital information (spreadsheets, formatted documents, images and so on).

49. Computer conferencing, if used as a primary medium of exchange in classes, can extend and enrich teaching (even for students on-campus) by:

-- opening classes to people with varying schedules, because each person can log on and review recent conversation whenever they like;

-- opening classes to people who are not in the same place at the same time, because each person can log on from wherever they find a computer and modem; in an institution with commuting or working students, this may be key to making possible group work by students who too rarely can meet together after class;

-- opening classes to people with accents that would interfere with communication if they had to rely solely on oral conversation (Hiltz, 1989) because participants can take as long as they want in order to study the (written) contributions of others and then to compose their own responses;

-- helping students who, for other reasons, may learn better if they have the option to listen deliberately and respond deliberately; and

- -- enabling faculty and students to use more collaborative forms of learning since the instructor's profile is lower in a conferencing environment: he or she, as just one more line of text on the screen, can avoid unintentionally dominating or squelching student discussion;

- -- helping students feel in touch with fellow students and faculty and less isolated.

50. One of the more suggestive pieces of research about the educational implications of computer conferencing analysed a class studying a second language. Students used computer conferencing and electronic mail to converse in the language they were studying, while the control group used a conventional audio-based language laboratory. The research showed, among other things, that the oral performance of the experimental group was superior. Apparently students from the control group, when asked to perform orally in class, had to worry about their accent, their speed of response, and, of course, how they were to express themselves. This probably rendered them less adept at expressing themselves orally and spontaneously in the second language. By contrast, the experimental group had plenty of practice expressing themselves in the new language as they planned parties, talked about topics due to come up in class and helped one another through the rough spots. For these reasons, the experimental group outperformed the control group (Smith, 1990). Virtually any new subject area is, in effect, a new language for the learner. Whether learning to express thought in a literary essay or in algebraic equations, students may benefit by practicing by conversing with one another in their new language through electronic mail.

51. The power of computer conferencing and electronic mail is also signaled by a recent evaluation of a set of virtual colleges and universities in the United States. In 1990, the Annenberg/CPB Project helped these institutions begin to offer "New Pathways to a Degree" that were supported in these four dimensions of interaction. An external evaluation investigated faculty and student assessments of the various types of real-time and time-delayed communication. Students studying off-campus and their instructors each compared the technologies they used to face-to-face communication on campus. A large majority of students and faculty agreed that electronic mail provided communication that was the same or better than on-campus communication in its frequency and its usefulness (Markwood and Johnstone, 1994, pp. 140 144).

52. As global use of electronic mail increases, small group conversations can include widely-scattered participants. Collegial exchanges and expert consultations can occur inexpensively across national boundaries and time zones.

53. Although electronic mail and computer conferencing are the most widely used technologies for distance learning, fax is also in common use to support conversations in many countries, especially for the exchange of homework. There is growing interest in the use of voice mail also. Modern digital systems enable faculty to create "mailboxes" for each student. For example, students learning a second language call their mailbox and record their homework; later the instructor calls the mailbox, listens to the student's recitation, gives feedback, and then listens to the next student's recorded homework (e.g. "Using *French in Action* ", 1992)

Tools and resources for learning by doing

54. Some of the most important and enduring learning is done when the student works more or less as an apprentice: carrying out complex tasks similar to those that he or she will perform after graduation. These tasks will be as varied as the aims of a post-secondary education. Because many of them require

technology, old or new, after graduation, learning the tasks usually requires technology, too. Sometimes the technology is as simple as a pencil and paper for writing a poem. Sometimes more is required.

55. Modern technologies offer cost-effective possibilities for learning by doing because machines such as computers and VCRs can be used in so many courses by changing their software. High-speed computer networks offer access to even more varied tools and resources. Global internetworking is expanding so rapidly that each day sees the addition of new archives, computer-based tools and human resources. The World Wide Web of information resources, initially created in Switzerland, is a hypertext of interconnected texts, images and computer-based capabilities such as simulations.

56. Once again the old "either access or quality" tradeoff is transcended. Learning by doing can be both enriched and extended when widely scattered learners have access to basic hardware and software, either directly or by network connection. Of particular use is worldware: hardware and software originally designed and marketed for purposes other than instruction. In many countries worldware is used more often for instruction than is courseware specifically designed for instructional use. The most common types of worldware are familiar to all: word processors, spreadsheets, statistical packages and the Internet itself. Also in frequent use are more specialised types of software such as computer-aided design software, music synthesizers and molecular modeling packages (Morris *et al.*, 1994). These tools and resources are cost effective for several reasons:

-- Whether worldware is developed for (well-funded) faculty research or (lucrative) business applications, multiple producers are probably racing with one another to produce faster, more powerful, less expensive packages that run on multiple platforms. New versions will usually run files from older versions and even from competitor's packages. Instructional staff can be relatively confident that, if they invest time in rethinking portions of a course to take advantage of worldware, they can use the new course materials for as long as they choose, even as computers and operating systems change.

-- Worldware is often multi-purpose, which makes a bigger market. Because most worldware takes the form of tools or resources, rather than being shaped for instruction, it is likely to be more flexible in application than courseware. The same worldware can be used for different purposes by instructors with entirely different instructional approaches to the same course and for many different courses as well.

-- Students come in already wanting it, increasing demand and returns to scale. If people in the professional world are using new tools to think in new ways about their problems, and even to tackle new problems, they will soon expect college graduates to already have learned the rudiments of those new ways of thinking. The undergraduates coming into the classroom expect to learn them, too.

-- Instructors already know about worldware, too. Because of the software's popularity in the professional world, instructors may already be familiar with it and perhaps even use it in their own research or consulting. Even some students may already have learned to use the worldware earlier in their education, reducing class time needed for training.

-- Because worldware lives from a large market, its marketing, technical support, reliability, ease of use and life expectancy are all likely to be superior to the average piece of software crafted by educators for students.

Directed instruction

57. The most widely used technologies for directed instruction continue to be the lecture and the textbook. In order to make directed instruction richer and more accessible, post-secondary educators are increasingly turning to preproduced video and also to live one-way video with two-way audio. Preproduced video has at least three major advantages as an instructional medium:

-- material can be introduced that students in campus-bound settings would typically never see: historical footage, microscopic close-ups, computer graphics, world class lecturers;

-- the instruction can be "paused" or reviewed as often as the student likes, and viewed at times most convenient for the student;

-- inadvertent errors in presentation can be avoided or edited out.

58. Live video has the advantage of enabling the instructor to do "just in time teaching", incorporating the day's events and reactions to what students seem to be understanding. A few distance learning programmes and lecture halls now make response keypads available to students; hundreds of learners answer multiple choice questions posed every few moments by the lecturer, who can then get an instant profile of what the class understands. In some systems, students can also push a button that means "when you have a moment, I have a question".

59. Two-way video is sometimes used for lectures with an extremely modest feedback capacity, but oftentimes this may not be a good use of resources; one-way video with audio feedback augmented with fax may be just as effective and less expensive.

60. Because of the expense of producing reliable, user friendly courseware, the development of disk-based bodies of courseware has not thus far approached the volume of courseware developed for video and print, but there are some early signs that situation may be changing. Although the most common uses of computer software are for "learning by doing", especially through worldware, faculty do sometimes create course-sized bodies of material that rely partly or wholly on computer software, and some of these packages have been in successful use for many years at many institutions (e.g., Morris *et al.*, 1994).

61. This discussion of directed instruction requires a cautionary note. Ever since the invention of lecturers, auditoriums and textbooks, directed instruction has been the most visible feature of post-secondary education. That visibility and the obvious importance of directed instruction sometimes mislead people into thinking that directed instruction and education as a whole are identical. The exercise in back-to-back drawing illustrates how inefficient directed instruction can be without interpersonal feedback. Nonetheless, there are potent reasons why its importance tends to be over-emphasized:

-- Directed instruction can operate economically on a large scale and, as needed, reach distant learners. Once the auditorium is built, it costs no more to lecture to 100 students than to 10. Once the book is written, it costs no more to sell it to 10 000 students than to 100. Once video materials have been created and broadcast, it costs nothing if millions of people watch

instead of a few. Since tuition per student is the same for the tenth and the hundredth student, but costs for the 100th student are, in effect, less, directed instruction has the lure of providing a cost-effective way of teaching large numbers of students, even over distance.

-- Many tests emphasize memorisation and simple, rote methods of solving problems. Directed instruction may be an adequate way of teaching at this level of learning. Thus programmes that employ only directed instruction, with little learning-by-doing and little person-to-person interaction, may appear satisfactory if measured only with such tests. However, when students are tested for higher order problem solving abilities -- the kinds of skills likely to be even more important for the 21st century than they are today -- programmes relying exclusively on directed instruction may not look as good.

-- Instructors and students have been known to indulge in a silent conspiracy to emphasize directed instruction. It can be easier for the students to believe that the learning that matters most is what the instructor tells them. Thus, it can be easier for faculty to accept their position as "sage on the stage", accepting that some students learn more than others in that setting. Although "teaching as telling" has long been discredited in the research literature, it is still widely practiced.

-- Early applications of the new technologies also lent themselves to directed instruction: videotapes for training, programmed instruction and computer-based drill and practice, simplistic laboratory simulations. Computer-based drills and tutorials have been shown to be about a third faster and more effective than traditional ways of teaching the same material, but the same limits on broadcast-only instruction apply; the learning is limited to topics where the computer can supply appropriate feedback a high percentage of the time. In those circumstances, software can provide a powerful adjunct to other methods of instruction.

62. If a wide range of types of learning are to be supported for a wide range of types of students, directed instruction should be complemented by the three other forms of interaction: learning by doing, real-time conversation and time-delayed conversation.

Section 5: What are the Missing Links?

63. This report has now summarized a puzzle about teaching and learning. First it described a Triple challenge that post-secondary education in many countries must somehow deal with: how to open access to all adult learners, especially the New Majority who previously were excluded or marginalised, how to provide all these learners with an education that prepares them for the 21st century and how to do both those things when costs must be tightly controlled.

64. Second, the report has asserted that a high-quality education has four facets: directed instruction, learning by doing, real-time conversation and time-delayed conversation. The report described technologies capable of supporting more accessible, and richer, forms of each of these four types of interaction. The third report in this volume, "The Future of Technology in Post-Secondary Education", addresses the problem of developing technological infrastructure. This first report will simply assume that the institution, province or country can supply suitable, affordable technologies that support the four facets of interaction, for at least some students and at least some courses of study. But supplying the technologies is the

beginning, not the end, of dealing with the Triple challenge. Hard-won experience teaches us that merely providing technology does little if anything to improve education. There are links in the middle of the chain of cause and effect that can lead from technology with the *potential* of supporting enriched, extended, affordable education to *actual* improvements that meet the Triple challenge.

65. Hardware and software do not determine how teachers teach, how learners learn or what education costs. The response to the Triple challenge is determined by the ways students, educators and policy makers use the opportunities that technology (old or new) provides and by the way they cope with its weaknesses. These are the "missing links" in the model being developed in this report.

66. How might one judge whether a particular "link" (i.e., a teaching practice or way of organising learning) would help institutions respond to the Triple challenge? Four criteria are particularly useful in understanding just what sort of restructuring is necessary:

-- Restructuring should result in enhanced involvement in learning and increased time on task. Most research indicates that, the more time students spend studying and the more of their energy and intelligence drives that study, the more they will learn. Any change in structure or practice should therefore motivate students to study harder while removing barriers to time spent in study.

-- It should foster intimate faculty-student and student-student interaction on a large scale. These two conflicting requirements must both be met. "Large scale" is likely a requirement in order to manage costs per graduate, since most educational institutions are labour-intensive; thus class size must be larger rather than smaller. Yet research also shows that intimate interaction (instructor-student and student-student) are key to learning for the average student, especially for higher order skills. For example, most faculty lack the information needed to understand accurately what their students actually know and can do; research in physics and other fields reveals that even students who get high marks on tests actually do not understand some of the most basic ideas under study. Good instructors study their students intensively, as groups and as individuals, in order to help them learn. What sorts of practices and structures enable such intimacy on a large scale?

-- Restructuring will involve simple but pervasive improvements in teaching and increased coherence in courses of study. It is difficult to find research identifying isolated assignments or even isolated courses (i.e., classes) that by themselves have an intrinsically valuable impact on the life of the average learner. Ordinarily such an impact requires a number of courses that coherently develop important skills. By the same token, access to education, if only one course, is accessible. Nor are costs brought under control simply because one class is offered in a more cost-effective manner. Continual need for a technology can also justify greater investment in its acquisition and mastery by students, staff and the institution itself. Adults may also be more likely to register for courses if they see a clear, swift pathway to a degree or certificate beyond the initial costs and risks[5]. What sorts of changes in instructional practice and organisational structure are potentially coherent and pervasive enough to enable post-secondary education to respond to the Triple challenge?

-- Restructuring should increase equity of access. One of the several motives that governments and institutions have for meeting the Triple challenge is to provide educational services more equitably and broadly. It has been said that the rich get richer, the poor poorer. Institutional

response to the Triple challenge must consciously be devised in ways that assure equity of access; otherwise the opposite result may occur.

67. These four criteria direct our attention to three "missing links" -- aspects of a restructured post-secondary course of study -- that would help institutions meet the Triple challenge: *1) a greater emphasis on project-based, collaborative learning, 2) certain changes in content, and 3) a division of labour that enables intimate student-student and faculty-student interaction on a large scale.*

Project-based, collaborative learning

68. Many faculty and researchers have pointed to a need to shift some instructional energy away from lectures and simple problems towards more emphasis on students working alone and in teams to frame and work on significant, realistic, open-ended projects: musical compositions, scientific investigations, software development projects, essays, social problem-solving, as appropriate for the student's course of study. One such project is not enough. Whether for learning in the major or as part of a general education, the student needs to work on a sequence of such projects, time after time, and in course after course in order to develop needed skills and insights.

69. Such projects can help students learn skills of higher order reasoning, gain deeper understanding of basic principles and examine questions of ethics, aesthetics and social implications of professional work. Projects can be used to show how various disciplines can relate to one another. Finally, projects can often engage students' interests and energy more effectively than lectures. Such projects should involve:

- Searching, sifting, analysing, and synthesizing large quantities of information.

- Designing and composing, i.e., complex and highly personal processes of analysis and synthesis, replete with trial and error, as students work to create a "product". While designing, students must also learn to attend to such subtle issues as the expectations of their intended audience, constraints imposed by a fixed or flexible purpose and an internal sense of aesthetic satisfaction or closure (Balestri, Ehrmann and Ferguson, 1992).

- Teamwork, both to help students learn skills of working with one another and also to help each of them to learn to become more critically conscious of the difficulties and possibilities of working with people whose backgrounds and personal characteristics are different from their own. In many countries one of the most distinctive changes in the workplace, other than increased use of technology, is the increasingly prevalence of a multi-cultural workforce. Collaborative work is also useful as a means of learning, according to many researchers, even for students who profess not to learn well in groups.

- The exercise of higher order thinking skills such as critical thinking.

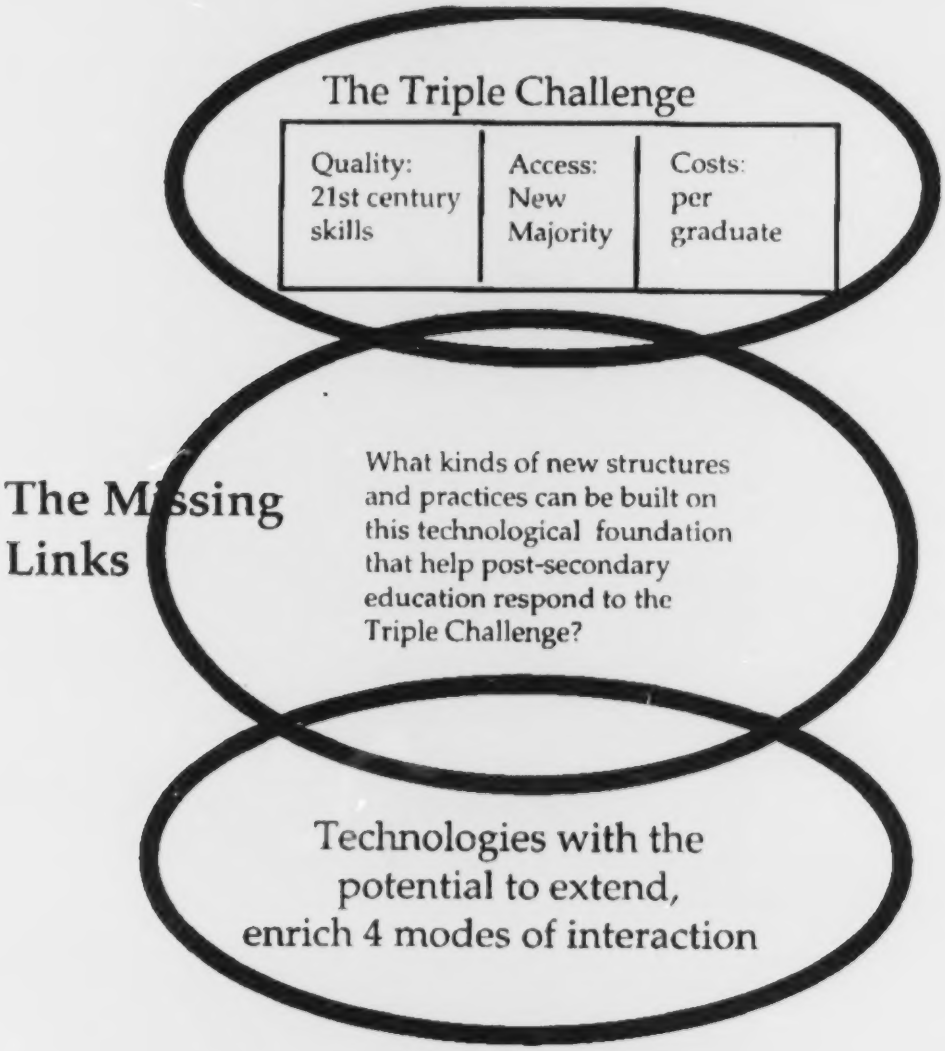
- Learning how to take responsibility for learning in an information-rich, tool-rich environment, e.g. deciding what must be learned in order to complete a project.

70. These skills are not generic; skills of problem-framing or teamwork or learning-how-to-learn manifest themselves differently in different disciplines. Thus each major course of study must consider how to strengthen student learning in these areas. Furthermore, since 21st century skills such as the ability to

work in teams are relevant both to one's work and to thoughtful, informed participation in social and political life, collaborative work ought to be part of both the major and general education. The same is true of many other 21st century skills: change is needed in both general education and the major. As already noted, faculty find it more feasible to assign students to work on ambitious projects when students can use worldware and the growing family of networks, including on-line libraries (this is not to imply that such projects are easy, for either the faculty member or the students! Their difficulty can be part of their appeal if the project's content is intrinsically interesting).

71. Another reason to attend to student-student interaction, including outside class hours, is because of the need to support work on projects. In many institutions without such arrangements, faculty cannot assign students to work on complex projects because, as soon as class-time ends, students scatter to their homes and workplaces. This, in turn, blocks some of the most important facets of learning from ever happening. Students need to be able to converse in real-time and with time-delayed media (making thoughtful collaboration possible even when schedules don't mesh). If appropriate arrangements have been made, students can use the same communications media to consult experts from the world of work as they develop projects; such experts can also play a role in the assessment of the finished projects, giving the whole enterprise further realism and legitimacy in student eyes; by using networks to send the work to experts and to receive their feedback, the process becomes more efficient and more able to include experts who are far away, or whose schedule does not permit them to review student work during class hours. Such consultations can happen now on a small scale because so few students and faculty seek them; if they are to happen in greater numbers, it will require organized business-education partnerships.

72. Using the kinds of ideas briefly summarized above in the section "Intimacy on a Large Scale", large classes can work on such projects. At Rensselaer Polytechnic Institute in the United States, the spring of 1994 saw the first offering of physics to approximately 1 000 students, with only minimal lectures; learning was instead project-based and collaborative. Although the RPI programme was for students who study on campus (some of whom commute to residences some distance away), a similar approach could have been used for students who were more widely scattered, especially if they had access to a network of appropriate computers.


The Triple Challenge
Quality: 21st century skills
Access: New Majority
Costs: per graduate
The Missing Links
What kinds of new structures and practices can be built on this technological foundation that help post-secondary education respond to the Triple Challenge?
Technologies with the potential to extend, enrich 4 modes of interaction

73. There are implications for access: project-based collaborative learning can also be a powerful means of extending access to students who have not performed well in traditional instructional settings. In research done at the University of California at Berkeley, for example, Uri Treisman found that disadvantaged students had almost always failed basic science and math courses; by putting them through workshops that challenged them with problems more complex than standard courses, fostered study in groups, and helped them learn the unspoken wisdom of excellence, his programme produced levels of achievement rivaling those of any other group of students in the university. (Treisman, 1985; Watkins, 1989).

Update content

74. The preceding "missing link" strategy implies that the content of post-secondary courses of study needs to be reexamined: both vocational-professional courses of study and general-liberal arts education. While much of this reexamination lies beyond the scope of a report whose primary focus is on technology and the restructuring of the teaching-learning process, several observations are pertinent:

-- In order to master the means of inquiry, of designing and composing and of research, students need to make increasingly sophisticated and varied use of the basic tools and resources of those crafts over a substantial period of time. Worldware as varied as on-line research libraries and databases, statistical packages and computer-aided design software become more rewarding the more experienced and ambitious the student becomes. Thus it is important for courses of study to be coherent (to a degree) not only in their content, but also in their means of study.

-- In most countries it is increasingly important for adults, as workers and citizens, to function in a multi-cultural state. Adults who have completed a post-secondary course of study should be especially sophisticated in these regards. Fortunately, video and telecommunications are proving of special value in the study of new languages and cultures: the video provides an "inside" and authentic view of the language-in-action, while telecommunications provides a good medium for the acquisition of a second language and a safe environment for interaction among learners of different cultural backgrounds (e.g. Arias and Bellman, 1990).

-- The visual dimension of many disciplines is growing richer and more varied. In some fields this is because new computational abilities makes it possible to create visual representations of data and ideas that could only be expressed in text and numbers before. In other fields, easy access to high-quality images as well as to large bodies of text makes interdisciplinary inquiry easier. A single compact disc (CD-ROM) may contain not only many of the key texts needed by a philologist studying a culture, but also many of the images that were previously accessible only to art historians and archaeologists; armed with such discs, even students at an introductory level can ask questions that professionals may never have addressed before and be engaged by the thrill of real research.

Division of labour in teaching and learning

75. What sort of educational structure can support intimate faculty-student and student-student interaction on a large scale when resources are limited? Successful programmes of this type seem often to share several distinguishing characteristics. Course enrolments are large, perhaps because many adults can reach campus or perhaps because technology enables participation of widely scattered students. At the level of individual courses one often sees:

-- Centralisation of at least some of the functions of organising and presenting the course, to insure that least a minimum number of students are served. This may take the form of a multi-institution consortium where faculty from different institutions split the responsibility for organising individual courses that are then offered to all students in the various institutions. In some cases, an open university or other entity may design a course that is then offered to students in one or more countries. Sometimes the presentations in such courses are

transmitted via live video; at least as often, the presentational component of the course is developed in advance.

- The students in such a course (who may number in the hundreds or thousands) may be divided into many small study groups. Often members of each group interact on a face-to-face basis, although in some institutions they interact via electronic media. Interaction among groups may also be via electronic media (not excluding the telephone).

- Because these study groups may have significant responsibility, trained mentors or peer tutors may be provided by the institution. Alternatively, the students themselves receive formal training in collaborative learning, especially if the group is then to work without direct supervision.

- Because more responsibility needs to rest on the learners' shoulders for managing their own learning, the curriculum, teaching methods and course resources need to support the continuing development of such skills and motivation. This requires consistently giving students responsibilities for their studies. For example, in one instance in France, students studying in centres off-campus are given a physical problem (for example, where balls fall in a pinball machine) and simulation software, and challenged to develop their own theories of the problem that can be tested through the simulation; the students can communicate with the instructor by telephone. (Biolluz, D'Halluin and Gers, 1993).

- Some way of providing common context for these parallel, small group conversations, such as a common videotape or text that everyone studies and then discusses.

- A shared library or other collection of tools, resources and study materials that can be used to help a very diverse group of students pursue similar but not identical courses of study.

76. Institutionally this sort of large yet intimate education can take a number of forms. Here are a few examples currently in operation:

- The national Open University in the United Kingdom has regional study centres. About 15 per cent of its students (around 17 000 in 1992) are in courses that require use of computers at home to communicate with each other, local facilitators, and course developers through a web of computer conferences and electronic mail. Real-time conversation is done face to face at study centres and by telephone.

- One private institution in the United States (Rochester Institute of Technology) can offer upper division work for a Bachelor's degree to students anywhere in the world. Faculty prerecord lectures on video. Students interact in small groups both in real time (audio- or audiographic conferencing) and through time delayed conversation (computer conferencing). Tests are administered on-line. Fax is used as necessary to move homework.

- Regional government and national government combine to finance a video network connecting this rural province's colleges and universities to its high schools (Maine, United States). Students go to nearby high schools to watch the college course live and talk back to the instructor by audio connection. The high school also provides computers with modems, fax machines and proctors for examinations. Students use the computers to connect to an on-line

library catalogue for the whole province that includes all the books in the college and university libraries as well as the provincial library; students are mailed books on request.

-- In a Canadian province (Nova Scotia) with an important linguistic minority, a college has been created to offer courses in the second language. Two-way compressed video and audiographic conferencing link learning centres with the instructor of each course. Those courses with a highly visual component (e.g., trade courses) use two-way compressed video while others use audiographics.

77. Study centres can be important sites for group learning as well as providers of needed equipment, network access and proctoring services. Over 90 community teleservice centres in the Nordic countries provide village communities with access to data processing and telecommunication services, for example. The European Association of Distance Teaching Universities is planning a Europe-wide network of centres.

78. Which adults should benefit from such centres? If one relies on employers to allow their employees to use workplace equipment and network connections, limited education dollars can be spread further. But will the unemployed and employees of smaller businesses tend to be left out? Will depressed areas suffer? In the United Kingdom, the high price of most open and distance learning programmes was difficult for the unemployed to pay. Recognising this, a one-year pilot project of open learning credits was introduced by the Department of Employment and operated through the Training and Enterprise Councils. Such programmes tend to emphasize skills that governments see as important for "employability."

79. At some point in the future, the home may furnish adequate technology and network infrastructure, reducing the need for such centres. Of course, the need for places for group meetings, distribution of physical materials and proctoring of examinations will remain. Even that day is far off, however.

80. In the meantime, political and institutional leaders ought to join in planning ways of sharing the burden of establishing and maintaining study centres which then can offer services from multiple providers. In many cases it may make sense to establish such centres in high schools for use during the evenings and on weekends. In other cases, community or corporate facilities might be used; shopping malls have also been used as the site of study centres.

81. In designing and equipping study centres, just as much attention should be paid to student disabilities as for students living and studying on a campus. Each disability needs to be considered separately. Equipment and software that can provide special advantages for one group (e.g., graphical user interfaces) may pose difficult barriers for another (e.g., blind students). Technology has the promise of raising doorways and lessening or eliminating the handicaps that formerly were the inevitable companions of disabilities, but that will not happen unless special care is paid to each population's particular problems. Highly accessible programmes can be quite helpful for students with special needs. In Japan, for example, the percentage of handicapped learners of the enrolment at University of the Air is ten times that at traditional universities and junior colleges (Mohri, 1993).

Implications for the Instructional Staff

82. In addition to the foregoing changes in teaching and learning practices, important changes are needed in patterns of faculty work such as:

-- Role transition from "sage on the stage" to "guide on the side". Especially if directed

instruction is shared among formerly separate classes, while the proportion of time spent working on projects and in groups increases, the character of teaching for most instructors will shift towards coaching, critique and the design of good projects.

-- Greater likelihood that instructors will need to work as part of an instructional team since there may be more than one instructor per team. One study of instructors teaching in both this sort of environment and also in more traditional settings on campus found that instructors usually like this support and missed it when teaching in traditional classrooms. That was especially true for faculty who had begun to depend on technology; in the restructured setting there was almost always someone with them, if only electronically, who could help if there were a technical malfunction or other unexpected event. In contrast, in the traditional classroom, the instructor had to fend for him or herself (Markwood and Johnstone, 1994).

-- Increased ability to get feedback on their teaching from students and peers as influenced by uses of technology such as conferencing systems and electronic mail. Self-assessment is also easier when instructors can see videotapes of their teaching and can study transcripts of their e-mail interaction with students.

-- Teaching often becomes a more public activity depending on the technology used and the way it is used. Some institutions teach over live cable television systems, for example, in which case the public as well as registered students can watch classroom sessions. The tensions in this issue become more apparent where the degree of "public-ness" is under faculty control, as when the lectures are offered over closed-circuit video networks so that students do not automatically have the ability to tape the lectures. Some instructors are reluctant to allow students to have tapes. Several reasons are cited for this reluctance: a) their desire to have students attend class and interact with others at their sites and across the network rather than view the tapes later and alone, b) they and their institutions might be made to look bad if a single tape were seen by non-students, and c) the tape might contain valuable intellectual content over which they would like to maintain control. Other instructors, of course, disagree, arguing that such tapes are valuable for reasons already discussed above in the analysis of directed instruction; some of them also profess to like the idea that others may watch the class and perhaps learn something and even develop an interest in registering for future classes.

Section 6: Strategies for Creating the Missing Links

83. To summarize, this report has suggested that a restructured post-secondary educational programme will likely feature pervasive emphasis on project-based collaborative learning, updated content and a new division of labour in teaching and learning.

84. If this sort of restructuring is to occur, several crucial kinds of support are needed, including:

- attention to the ways materials are developed;
- the ways that instructional staff themselves learn;
- the ways the emerging programmes are evaluated.

(Other issues more directly concerned with infrastructure and technology are discussed by William Renwick and Jacques Hebenstreit in the second and third reports which follow).

Supporting materials development and upgrading

85. Earlier this report urged educators to focus their attention mainly on worldware, despite the fact that worldware, by definition, is not designed for directed instruction. Directed instruction remains necessary, however. What sort of materials are needed? Assuming that education needs to add technology-based materials to a mix that will continue to include print textbooks, what are these technology-based materials most likely to look like? How should be they be financed, developed and distributed?

86. There are barriers to the viability of educational software. In trying to understand what sorts of instructional software deserve development and support, it is important to realise that, whatever else it looks like, such software must be capable of being used for a long time and in many places. Post-secondary courses of study change very slowly (Woodrow Wilson, while president of Princeton University, once likened this task to moving a graveyard). Several decades of experience indicate that long life and wide use are very difficult criteria for software to meet. Many factors tend to prevent video and computer software from achieving that level of use:

- Video use can be limited because video reveals much about the time and place of its production. Frequently those particulars quickly make it seem dated, or foreign, to many users.

- Computer software can be made swiftly obsolete by changes in the computers themselves and in their operating systems. Upgrading software to cope with such changes can sometimes exceed the original costs of development. This is unfortunate because many of the explicit and implicit subsidies that finance the creation of software are not available for its upgrading and porting; for example, grant making agencies are usually more attracted to revolutionary instructional advances than to expensive upgrades of aged materials. Instructors who are pleased and proud to produce innovative version 1.0 may find it considerably less rewarding

to create and support version 3.0 when ideas for entirely new software compete for their time; their colleagues, too, while unlikely to consider version 1.0 in promotion and tenure decisions, are even less likely to consider version 3.0 important. On the contrary, instructors often seem to be penalised for spending their time on such software development rather than on "important" activities such as research in their disciplines. The same is true for highly produced video courseware; updating can easily be as expensive as the original production yet far less glamorous.

-- The difficulty of upgrading makes discontinuity more likely, each package different from others, and different from its precursors. Thus, in contrast to worldware, software designed for instructional use is usually unfamiliar initially both to instructors and students. Both groups must be persuaded to become familiar with it and to use it, and this often doesn't happen. Learning new video or computer software is usually difficult. It is difficult to skim, so even glimpsing its capabilities make take many hours. Learning the nuances is even more difficult, especially since the user interface and instructional philosophy are often different for each different package of software.

-- The tiny market for each piece of software, its short life span and the frequency of illegal copying, all discourage private sector investment in post-secondary courseware.

87. A recent study (Morris *et.al.*, 1994) indicates that, despite these formidable barriers there are, in addition to worldware, several families of software that are both of demonstrable educational value and also widely used. These families of software deserve special attention as educators and governments consider how best to respond to the Triple challenge. These families of software include:

-- *Student editions of worldware*. These packages are developed or at least marketed for instructional use, but bear a strong resemblance to worldware. They may be current or old versions of worldware sold at a student price. They may be developed by faculty with simpler interfaces or adjunct instructional materials. Student editions share many of the advantages of worldware such as the hidden subsidy of research, development and marketing.

-- *Niche curricular software*. Developed and marketed for very little money, these packages are also acceptably inexpensive to upgrade. Sometimes they make money, but sometimes their developers keep them alive because of their passion for the subject. Seldom of revolutionary impact, they are more likely to provide modest labour-saving or instructional impact and to fit painlessly into relatively traditional programmes. In sum, this software is useful, but is not likely to be crucial to restructuring post-secondary education.

-- *Course-sized bodies of materials* are occasionally viable. Of special interest are materials designed to help institutions increase enrolments by supporting students who seldom come to campus to study. If institutional budgets depend on enrolment, they have sometimes found it worthwhile to share in the development costs of such courseware in exchange for free or low-cost use of the resulting materials; improvements in enrolment help justify the up-front investment in the materials.

In courses providing directed instruction with relatively stable content to large enrolments, with faculty playing a tutorial and support role, packages of high-quality course material (print, video, audio, software) can provide a full course of relatively independent study for

some students while being used for many other purposes as well. Materials from the British Open University are used in traditional settings elsewhere in the United Kingdom and elsewhere in the world.

-- *Extensible software.* This small, but growing, family of software is of special interest for meeting the Triple challenge. Extensible software is software that can easily be expanded and upgraded because of its underlying architecture; its structure also tends to make it exceptionally flexible for use in multiple settings and for multiple purposes. "Slice of Life" and "BioSci", for example, are two extensible "student editions" that are both biology videodiscs. Both are a decade old and in wider use than ever before. Each one is an archive of slides and short motion segments. Because of this "slide archive" architecture, they can be easily expanded by adding new slides and new motion segments. "Slice" is in its fifth edition, and grows by attracting contributions of slides from its own users.

"Perseus" is an extensible CD-ROM and videodisc for the study of classical Greece. Version 1.0 contained the largest collection of images of classical Greece ever assembled; version 2.0, to be published early in 1995, will contain four times as many images. Perseus also contains a huge collection of Greek texts and translations, along with software and on-line references. The power of its underlying architecture is demonstrated by the fact that its original development cost over $2 million, while its port to a Windows operating environment will cost approximately $50 000. It is also relatively inexpensive to design instructional software that gives students well-structured introductions to the larger ideas and resources of software such as Perseus, with "hooks" that guide the student into and out of the database.

Another example of extensible software that, like these other examples, can grow by accretion is CUPLE, the Comprehensive Unified Physics Learning Environment. CUPLE includes a multimedia hypertext for the study of physics, laboratory software and software for simulations, all integrated but all capable of growing by accretion. Like Perseus, CUPLE has already grown considerably since its initial development stage and shows promise of growing for many years to come.

Both Perseus and CUPLE have attracted interest from developers in other countries who may add materials to their basic structures.

Extensible software, if properly designed, may be a key to helping post-secondary education meet the Triple challenge; it can support student work on projects but can also, as in the case of CUPLE, include flexible instructional materials.

88. A huge problem is that no one has enough money to develop all the needed materials. This vacuum has encouraged growth in international co-production. The European Association of Distance Teaching Universities has produced a second-level humanities and social sciences course entitled "What is Europe?", which is being taught in three different languages. The Knowledge Network in Canada engages in similar co-productions. The European Association of Users of Satellites in Training and Education Programmes (EUROSTEP) project, originally funded by the European Space Agency to encourage use of its Olympus satellite, is an effort in international distance learning collaboration, both in production and in distribution of materials.

89. The Annenberg/CPB Project in the United States is collaborating with producers in Europe, Japan, and Australia to develop several new courses for use in distance learning and campus settings. In a new course on world regional geography, for example, producers from six countries are each filming in a wide range of countries under the guidance of a common plan. The Annenberg/CPB Project has two other points of interest as a model for how governments, educational consortia and private donors might support the development and distribution of long-lived, widely-used media-based materials.

90. First, the materials it produces have multiple uses. Ordinarily one assumes that instructional materials are quite specialised. Annenberg/CPB materials exemplify the possibilities of multiple use. Video and other study materials from the Annenberg/CPB Project are used not only for distance learning, but also by millions of students on campuses, tens of millions of informal learners who watch the materials as they are rebroadcast on public television in the United States and learners of all kinds in almost a hundred other countries around the world.

91. Second, the Project exerts considerable control over the materials it develops, has responsibility for their distribution, and retains a share of the resulting royalties. Although materials are sold at a loss, with income that covers immediate expenses but only a fraction of development costs, the staff is nonetheless motivated to expand income by expanding distribution; the income itself is plowed back into marketing and into new projects. Thus the original funding (in this case an original gift of $84 million from philanthropist Walter Annenberg) resulted in revenues sufficient to support all product marketing and support, as well as to fund the development of a new generation of multimedia materials in the years since the original grant ended.

Faculty and staff development on a large scale

92. No one is more critical to the operation of the educational system than the instructional staff that organizes and teaches the program. Yet few if any countries are handling the problem of helping instructors learn to teach in the new environments, and rethink courses on a national basis. Exceptions include the United Kingdom, which has a Computers in Teaching Initiative with disciplinary centres, each with national responsibility, sited at different universities; each provides training, support materials such as newsletters and consultation in its field. Australia is creating faculty development materials for national use. The Annenberg/CPB Project is funding some projects (some international) whose primary aim is to help educators learn about technologies or to think together nationally about how to restructure particular courses. Many countries have specific projects to spread particular techniques or software. But none have the kind of ambitious programme that is needed to help a substantial part of its instructional corps go through what is almost a career shift.

93. Such a programme would need two distinct components, one component focused on learning about technologies that have only recently become truly available for post-secondary instruction, the other component devoted to supporting the rethinking courses of study in ways made possible by those technologies.

Learning about emerging technologies

94. Predictable progress in digital technology enables unpredictable changes in how those technologies might be used. Thus, a single injection of "technology knowledge" is not sufficient. Instructors need to learn continually about the ever-changing possibilities of new technologies. Expertise in using spreadsheets does little to inform instructors about the possibilities of the Internet. In future years, knowledge of the Internet will still be valuable, but will not eliminate the need to help educators learn about expert systems.

Rethinking courses of study: sharing information about technology, technology-based materials and teaching

95. Even this group of motivated faculty at reasonably well-equipped institutions face daunting problems if they wish to restructure their courses. Imagine a instructor who wants to organise a lower division biology course around student research (literature-based research plus real and simulated experiments). Here are a few of the questions that such instructors today must answer on their own, usually by trial and error:

-- There are many useful technology-based resources for such a course and such students (e.g., documentary videos, computer simulations, databases on the Internet, packages for data analysis) but what are they, where are they, and what is each one good for?

-- What kinds of higher order skills and insights is it feasible to expect these students to develop and what sequences of projects seem successful in developing them? How should assessment of student learning change?

-- Week by week during the semester, what's most likely to go wrong? If properly dealt with, do any of these problems represent instructional opportunities?

-- Some students are quite adept in using particular pieces of hardware and software, while others are novices. How should the instructor design this course so that these differences in the students' skills are not a distraction?

96. Further complicating matters is the fact that these answers don't "stand still". Each year brings new technology-based opportunities and fresh understanding of what can be done with last year's opportunities. In the past, instructors could teach more or less as they were taught. Today, with technology powering rapid change in research, in the workplace and in society, it becomes necessary to update teaching far more substantially and frequently.

97. It is crucial to elicit fresh thinking about how instructors within and among countries might work together in order to update standard courses of study on a continuing basis. Such international efforts to restructure courses where students make extensive use of technology are almost without precedent. In some cases it might involve joint production of materials, but more often the efforts could and should focus on sharing information about existing materials and emerging modes of teaching. The joint effort might develop workshops to help engage a growing number of instructors in the newer ways of teaching the course.

Evaluation and the creation of leverage

98. Educators and government agencies usually must work "in the dark" as they invest in technology. It is rare, for example, to know with any precision how educators and students are using the technology they already have, and rarer still to have a sense of the benefits and costs of those uses. As a result those who invest in technology and its uses are forced to grope their way forward, as people feel their way through blackened rooms full of obstacles. In such a setting proper evaluation procedures are as vital as flashlights, illuminating at least some of what lies ahead. As yet, however, very few evaluation procedures exist that enable educators and governments to see what's important.

99. For example, this report has stressed the importance of project-based collaborative learning and increasing student time on task; those are two issues that ought to be monitored by any institution or government that conceives itself to be moving in these directions. There is no commonly accepted procedure for assessing change in these areas, however. Fortunately these issues are likely to be of great concern to educators in many institutions and indeed in many countries. Post-secondary institutions should collaborate, perhaps with governmental sponsorship, in the development and application of such evaluation procedures targeted to monitor progress in the areas highlighted in this report.

100. Such evaluations would be especially useful in shaping and reshaping national policy and local practice. It would not be surprising, for example, to discover that investments in technology were failing to support increased use of project-based collaborative learning, perhaps because of failure to provide incentives to educators to rethink their courses. But once evaluation spots such a problem, the debate can begin about how to remedy the difficulty and speed progress.

Issues of pricing and trade

101. In addition to the issues raised in the preceding two sections, there are other, overlapping policy options concerning teaching and learning that ought to be considered by educational and political leaders, including the following.

102. Internetworking makes it technically possible to distribute academic resources for low marginal costs, often zero cost. In effect, educators and students can sit at computers linked to high speed networks and find the world sitting (seemingly) on their own machines. It is easiest to explore and exploit this world if on does not need to pay a fee each time a new document or service is used. But lack of such fees may discourage development of those very goods and services. Should there be a charge to users or to their institutions? If so, what expenses should the charges cover? Or is it more efficient to make the resources freely available (since the act of billing generates its own costs).

103. Should such pricing encourage or discourage the import and export of educational goods and services across national boundaries? Internationally, it is becoming common to use technology to import or export graduate programmes across national and provincial boundaries. As with international trade, the benefits of such specialisation of production and common use of products and services can be substantial. As previously mentioned, some countries have already begun coproducing educational materials. Policy makers need to decide in what ways and in what extent to either encourage or interfere with such "trade".

Section 7: Meeting the Triple Challenge: A Summary

104. How have the various policies and practice highlighted in this report make it more feasible for institutions to respond to the Triple challenge?

Accessibility

105. Adults, many of them using study centres, would be able to participate in courses of study that feature strong emphasis on project-based collaborative learning along with materials of directed instruction developed for large scale use, supported through real-time and time-delayed communications. Project-based learning is of particular importance because it can engage learners and foster excellence among students who may not have done well in classes that relied chiefly lectures and reading. Time-delayed exchange by electronic mail and computer conferencing also is of special importance for enhancing access, since many types of students seem to participate more fully in this medium than they are able to do in traditional face-to-face settings.

21st century learning

106. Project-based collaborative learning and updated content should help students acquire the kinds of higher-order skills of thought and action needed to function in a rapidly changing workplace and a multi-cultural political and social environment.

Costs per graduate

107. The report has, to this point, said little directly about how rapidly rising costs per graduate might be brought under control. Increasing amounts of money are being spent for information technology so, in one sense at least, technology is part of the economic problem facing post-secondary education. However, the same "missing link" strategies and technology investments that have been recommended for their benefits in enhancing access and enriching quality are also of interest for their implications in controlling costs. The implications for controlling costs per graduate include:

- Major reductions in attrition, due to the excitement and commitment that can be created by project-based, collaborative learning and the social bonds formed through networking; if more students graduate, the costs per graduate can be sharply reduced.

- Increasing average size of classes by enabling higher enrolments in classes that would otherwise be unacceptably tiny, and by making it feasible and effective to offer courses that would otherwise be unacceptably large by creating intimacy on a large scale.

- The possibility of reducing capital and operating costs when students are educated in "virtual space" rather than in brick-and-mortar facilities.

- Sharing resources through networks or inexpensive duplication that each department or institutions might otherwise buy or create separately.

- Reducing costs borne by students. One way to reduce student costs (applicable to working adults) is to reduce the time spent in completing the programme, e.g. by reducing time spent in commuting and increasing time spent in studying. If increased engagement and changes in policy make it possible to attain a degree more the adult may save in one of the most substantial costs of education, income that is foregone in order to pursue an education.

- If all these factors enable students to take more classes per year and work more quickly towards a degree, the institution can thereby control costs by using the same physical facilities to educate more students each year.

- The economic motive that compels much of the current and future expenditure on computing, video and telecommunication is clear. The investment is required to meet the first Challenge: to offer an education that is seen as up-to-date, and thus to avoid losing students who would otherwise attend other institutions, perhaps in other countries. To help control this large and essential investment, the Report has recommended that educators consider a curriculum that is, relatively, more coherent so that students the same multi-purpose technologies and technology-based resources repeatedly, gaining mastery over many classes. This strategy should be more cost-effective than strategies that ask faculty to create, and students to employ, different pieces of technology-based material for every assignment and every class.

Continuity and change

108. Institutions and countries can neither bury themselves in, nor totally forsake, the past. This report has argued that there is an essential continuity not only in how postsecondary education educates its learners, but also in how postsecondary education has changed, and continues to change. The strategies employed by countries and institutions will vary according to circumstance. The underlying trend is universal. The technologies that once helped lead education into cloistered campuses is gradually leading us beyond them. The technologies that once led education from conversation into the Grove of Academe to the lecture hall is now leading learners to a richer and more multi-dimensional relationship with experts and expertise.

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Notes

1. In addition to the contributions of the outstanding working group members, Jacques Hebenstreit, France and Linda Foa, United States thoroughly critiqued the draft report.

2. In this report, "graduates" refers to adult learners who have completed a coherent course of study. Such a course of study may consist of one or more classes, and may or may not result in the award of a traditional degree. It should, however, foster palpable, valuable learning on the part of its "graduates" which they can exploit in the worlds outside the classroom. It cannot be over-emphasized that the concern of this report is with attaining sufficient, deep learning that the "graduate" can function in new and different ways in personal, cultural, political, and economic life, with which students are privileged to pursue such an education (accessibility), and with much it costs to provide and pursue such an education (costs per "graduate").

3. Adapted from a tale first told by Richard Breitenfeld, President of WHYY, Inc. a public television and radio station in the United States.

4. This typology is explored more fully in Ehrmann (1990, 1992).

5. "New Pathways to a Degree" was an Annenberg/CPB Project funding program that supported development of degree programs for learners studying off-campus, with technologies used to support all four facets of interaction. External funding for the seven projects ceased in 1993, yet all seven programs are still going strong. It appears that one factor in their success was that they did offer a coherent pathway to a degree, with consistent use of their technologies (Markwood and Johnstone, 1994).

II. THE FUTURE OF FACE-TO-FACE AND DISTANCE TEACHING IN POST-SECONDARY EDUCATION

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Introduction

1. This report[1] discusses some possible institutional responses to rapidly changing demands and expectations in the expanding sector of post-secondary education in OECD countries. It focuses on the "delivery actors" -- the universities, polytechnics, colleges, learning agencies, training schemes, and various private sector initiatives -- that provide post-secondary education and training in its many forms. Specifically, it ponders answers to three questions:

- -- Who will be the delivery actors of post-secondary distance education?
- -- Is the dual-mode university (face-to-face and distance education) the likely future of all higher education institutions?
- -- What should then be the interaction between both modes of education, and the consequences on teaching staff, content, and design of materials?

2. There is a wider context within which answers to these questions are to be considered. The presiding theme of the CERI study is the impact of information and communication technologies on post-secondary education. Accordingly, this report considers the potential of two very different variables to influence institutional responses and policies: distance education and the educational uses of information and communication technologies. Educational usefulness is what links these two variables. While, therefore, there are many references to information and communication technologies in what follows, the touchstone is their present or presumed future usefulness for teaching and learning.

3. Another point of clarification needs to be made. There are educational technologies as well as information and communication technologies. In respect of the questions to be considered, technologies are by no means to be thought of solely as items of equipment and electronic networks. A technology is any systematic application of knowledge for practical purposes. There are technologies of distance education and of face-to-face teaching. They were developed before the advent of the information and communication technologies that now claim so much attention and they could function effectively without any significant contribution from them. One of the aims of the report is thus to emphasize that there are indeed two variables under discussion, both of which are to be discussed in terms of their present and possible future contribution to effective teaching and learning in post-secondary education.

4. The second of the three questions, furthermore, highlights the phrases "distance education" and "dual mode" and this foreshadows a discussion from a perspective that many might find surprising, even controversial. But the emphasis placed on distance education in the context of future possibilities merely reflects the way questions of educational policy are being put at the present time. Where, a generation ago, it was the policies and practice of conventional institutions that set the agendas for distance education, the reverse is now beginning to be the case.

5. The first half of the report gives reasons for that reversal. It is suggested, first, that the best

practice of post-secondary teachers, regardless of whether they teach face-to-face or at a distance, is based on some common principles of teaching and learning and, second, that advances in information and communication technology have the potential -- no more than that at present -- to make important contributions to effective learning irrespective of mode of teaching or the circumstances of students. Eight principles of good practice are outlined, showing how these technologies could be used by teachers who see themselves as facilitators of their students' learning. Brief mention is made of some of the opportunities and threats that post-secondary institutions now face as they review their institutional missions in changing circumstances. The three questions are then addressed and, with the aim of focusing further discussion, clarified as to what they imply for policies for the management of teaching and learning in post-secondary institutions.

6. Four themes run through the report. First, the phrase "distance education" is serving as a proxy for changes in teaching and learning that are more deep-seated and have as much application to the work of face-to-face as to distance teachers. Second, face-to-face and dual-mode institutions must examine and change their internal cultures in important respects if they are to improve the efficiency and effectiveness of what their teachers teach and their students learn. Third, publicly funded institutions in all OECD countries are constrained by the policies of the governments that fund them and are therefore limited in the policy initiatives they can take on their own in response to their changing circumstances. Fourth, the issues of modes of teaching, arrangements that give students more control over their learning, and the use of technology are essentially educational issues. But the infrastructures of educational research, curriculum development, and teacher development in post-secondary education are weak and poorly resourced. Institutional leaders and their teachers, and advisers to governments, are unequally placed when they are called on to make policy decisions that would commit them to greater use of information and communication technology to facilitate self-directed learning by their students.

7. The mood of the report is thus ambivalent. Developments in information and communication technology hold out great hopes, but for various reasons educationalists are hedging their responses. Experienced distance educators, for their part, are averse to panaceas and most are far from persuaded that information and communication technologies will deliver on their promises for educational purposes. Many fear that a discussion that focuses on information and communication technologies diverts attention from the real issues in their field -- issues which, if they are to be solved, call for a greater application of distance-education technologies which for the most part would be supported by low rather than high forms of information and technology. Hence the question in the title of the report.

Section 1: Changing Contexts

8. From its inception, the OECD has focused attention on a triad of overarching policy issues: how to promote research and development, how to apply innovations to national economic development, and how, through education and training, to increase human capital and direct its efforts to further innovation and economic development. The initial emphasis was on objectives, and the means by which they were to be achieved was left to experts in each sector of activity. Public education systems, for example, were expanded, restructured and developed, and they became more innovative, but the roles of teachers have remained recognisably the same. Increasingly, however, during the last ten years the international debate has been about means as well as ends. Experts are finding that they no longer have the last word on the way professional services ought to be conceived and managed in their own fields of professional expertise.

9. Three changes of global significance have created this new mind-set. In the first place, Marshall McLuhan's global village is becoming radically different in ways that were scarcely foreseen thirty years ago. Economic as well as social life is being transformed as computers create new forms of interdependence between knowledge and economic activity. Advances in science and technology are increasing the extent to which industrial processes are based on knowledge and driven by it. They are also increasing the speed with which knowledge and skill in workforces become obsolete. Debates about the half-life of knowledge now commonly question whether it is as long as ten years. There are fears that investment in research and development will not bring practical benefit without associated effort in the development of human resources. The implications for continuing education and training within industry are obvious. Enterprises based on information technology, furthermore, are becoming typically smaller and they depend on high levels of skill from all employees. More and more jobs require employees to make decisions and solve problems, and this requires continuous learning. Enterprises thus organised are showing that they can be more flexible than big corporations in their ability to respond to changing market possibilities, but this carries threats as well as opportunities. Employees can no longer look forward to an unbroken career with the same firm and the prospect of a retirement pension. The next strategic move by their firm might make them redundant. More than ever before since the late 1940s, individual workers are under pressure to take their own initiatives to maintain their employability by adding to their knowledge, expertise and skill. Again, the implications for continuing education and training are becoming obvious.

10. The second change is towards a much more acute understanding of the essentially global nature of economic competitiveness. Enterprises and nations are asking themselves, as never before, what they must do to achieve and maintain a competitive advantage over their rivals. A new form of social Darwinism has seized the imaginations of economic gurus and national leaders in which nations, with stark consequences for the well-being of their citizens, are contesting for the survival of the best adapted. It calls for strategies for the long haul and, among other things, recognises that forecasts of the changing age-composition of national workforces are of particular importance. With the number of new entrants to the workforce declining, national economies cannot look to them alone for new knowledge and skills, hence the importance of upgrading the qualifications of older workers. The hope for the future is that, taken as a whole, national workforces will be better educated and qualified, they will be able to adapt more readily to changing work requirements, they will be more self-reliant and thus better able to face threats of redundancy or unemployment, and they will have higher living standards. Within the European Union, it is important to note, this tension between global competitiveness and national well-being is tempered by the potential of a very large internal market. But the policies of the European Union are, in essential respects, national policies writ large, with the added benefits associated with regional co-operation.

11. The third change is ideological. Economic libertarianism has revived its credibility as a guiding light for government policies for economic development. More than that, in many OECD countries it is challenging long-standing assumptions about the way the state should make public services available to its citizens. Education systems in several countries are being deregulated and educational institutions are being cast in the role of competitors in educational market places. Students are being referred to as clients, institutions as competitors for market share. Governments are telling educationalists that education is crucially important and more of it is needed, but not more of the same. Many countries have introduced new funding regimes and forms of accountability whose aim is to steer educational institutions towards greater efficiency (in business terms) in the use of public funds. Regardless, however, of how they are going about it, or of their current levels of participation, all OECD countries are planning increases in their post-secondary sectors. They know they must become, in Torsten Husen's phrase, learning societies, that they must develop systems of mass post-secondary education and training, and that they must spend much more in future than they have in the past on continuing or recurrent education, second-chance education,

and on training within industry[2]. It is at this point that arguments based on economic development and those based on social equity find some common ground. There must be greater access to a wider description of post-secondary courses of education and training by women, disabled people, members of underprivileged minorities, and people living in depressed regions. There must also be greater equality of access between generations. For that to happen, spending priorities on post-secondary school education and training must change, and the expectation is that this will have to be done not by adding significantly to public expenditure but by redirecting money already committed to education and training. The highest levels of expenditure are associated with the full-time education of students in the 18-25 age group, particularly in universities. They are the subject of critical scrutiny in virtually all OECD countries, with the aim of reducing unit costs.

12. Post-secondary education is of course ceasing to be equated with the 18-25 age group and other full-time students. It is the diversity of post-secondary enrolments that now claims attention. Increasing numbers of students are adults over the age of 25 who may be making a late entry to higher education and who are more likely to be studying part-time than full-time. Their courses may be organised so that they can study off-campus, and many of these students will be enrolled in distance-learning programmes. In Australia, for example, 10 per cent of tertiary enrolments are distance-education students. Many of these -- and this is the case also in Canada and New Zealand -- live in university centres. The flexible nature of distance learning is what makes it possible for them to pursue their studies. And just as advances in information and communication technologies are transforming economies so, too, do they have the potential to transform teaching and learning as we have traditionally known it. It is possible for teachers and students who may be far removed from each other to interact by telephone, teleconference, radio, television and fax. Some can have access to computerised databases at times of their own choice. Developments in computers are giving a new meaning to the phrase "multi-media". It is now possible to assemble texts, sounds, still and moving pictures on the same hard disk, incorporate them in one message which -- cut, edited, copied, pasted and filed -- can be sent to another computer over a telephone line and used interactively by students. No less important, computerised multi-media products are becoming available at costs which, though still high, are rapidly decreasing, so that they can be used in small, portable computers that have more computing power than current personal desk computers. For most teachers and students these innovations are as yet on their educational horizon. But they foreshadow great possibilities for everyone engaged in post-secondary education, whether as teacher or student, and whether working primarily in face-to-face or distance modes.

13. We are living through a time of changing expectations. Where, previously, institutions of post-secondary education imposed requirements which their students were bound to accept, they must now (for the most part) respond to the differing expectations of more diverse student populations. From acting as if they were the central determinant of their students' lives, institutions are now in varying degrees adapting to the fact that, for many of their students, post-secondary study has to be fitted around the typical adult responsibilities of earning a living and pulling one's weight as spouse, partner or parent in the running of a household, to say nothing of wider community involvement.

14. Taken together, these changes raise fundamental questions for all institutions engaged in teaching and learning. Within education systems and within universities and colleges there is a growing recognition that teaching and learning are not synonymous. With this goes some acknowledgment that failure to learn is not to be attributed solely to deficiencies in the learner. There is in most OECD countries, too, a strong body of academic opinion that holds that a main objective in post-secondary education should be to enable students to take control of their own learning. Students should be empowered as well as enabled.

15. In the course of the last generation these issues have been the focus of much academic and public argument and they are still contested issues. The arguments centre on how far post secondary institutions, and universities in particular, should conserve traditional approaches and how far they should acknowledge a changing world and adapt to new circumstances. One thing, however, is scarcely any longer in dispute. The projected costs of systems of mass post-secondary education are enormous and it is generally admitted that they must become more cost-effective and do more with less. This is one reason -- and for governments and their advisers a very important reason -- why distance-education approaches are being given such serious consideration as policy options in increasing numbers of countries in the developing as well as the developed world.

16. Questions of productivity and quality are at the heart of the matter, and they are being asked in new ways. The question always asked of face-to-face teachers concerns the point at which their effectiveness falls away because they have too many students to cope with. Quality is a function of interaction with a good teacher. But with distance-learning programmes -- and it is the same with other forms of independent study -- the question is how many students can interact effectively with a good learning programme and its associated tutoring arrangements The expectation is that, with quality held constant, good learning programmes can be more productive than good face-to-face teaching. Note, too, the shift from teacher to student as the active participant.

Section 2: Locating the Issues

17. Two different but increasingly related issues are at the heart of the questions posed in this report. The first is the relative educational merits of distance- compared with face-to-face methods of teaching and learning. Up until the last few years, it has been an issue of more concern to distance educators who have had to justify what they do in comparison with the traditional work of face-to-face teachers. As an issue it touches deeply-held attitudes about education, knowledge and teaching, particularly in universities. The conventional premise of discussion is that the norms of good teaching are to be found in face-to-face modes and the onus is on distance teachers to demonstrate how far they are able to meet them. The second issue concerns the educational potential of the information and communication technologies that are now available or becoming available for wider use. The second issue is now strongly influencing debate about the first by pointing up the sophisticated flexible, interactive possibilities of distance-learning approaches that harness communication and information technology for educational purposes.

18. Teachers usually find that they cannot discuss these issues without reference to their deepest feelings about what it is to be a teacher. The key words -- education, instruction, teaching, learning, knowledge and information -- are all highly evocative and they are inescapably normative. Discussion cannot avoid turning on what *ought* to be the case, depending on the value allegiances of those taking part. Where, furthermore, the focus is on distance education, discussion often takes place in contexts of advocacy: there are positions to be defended, consolidated, undermined. Usually, too, such discussions are associated with matters of policy: decisions are to be made about how an education system or an institution should face its future, and choices are to be made as to where resources should be put and for what purposes. Victory for one side of the argument may mean more than defeat for the other side. It may mean the loss of a claim to funding, teaching and other resources.

19. Much can depend, too, on which word is under discussion and who is interpreting it. Face-to-face

teachers can talk about teaching and learning without having to make any reference to distance-learning, to off-campus students, or to such notions as "single" or "dual-mode". This is not so with discussions of "distance education", which is usually defined in ways that acknowledge the separation of teachers and students in time as well as in space. Off-campus in this discourse is by definition not on campus. The notion of modes of teaching and learning implies comparisons, and comparisons must then be made in relation to criteria. And when criteria are invoked, the proponents of face-to-face teaching and campus life have in the past invariably occupied the educational high-ground. The criteria of good or preferred forms of post-secondary education are usually written in ways that privilege face-to-face teaching on a campus. They also have connotations of advantage and greater benefit. To be enrolled as a student on a campus is to be advantaged. Distance-education approaches have been devised with the aim of reducing the disadvantages of those who are unable to be enrolled on a campus. Whether such disadvantages can be removed entirely is highly disputed, differences of opinion again turning on different value allegiances concerning what "good" or "real" post-secondary education is or ought to be.

20. Education is usually thought to comprise more than the sum of the subjects or the modules of work that students will complete to standards set by their teachers. One's education has sometimes been characterised as what remains after one has forgotten everything one has been taught. There is, on this view of the matter, a moral, value-laden component that is even more important than instrumental knowledge and skills. Instruction, on the other hand, is often thought of entirely in instrumental terms[3]. The aim is to bring students to the point of satisfactory performance, and the criteria to be met are intrinsic to the discipline or the task. Education, in the belief systems of many university teachers, is what universities impart : instruction is what takes place in technical institutes, trade schools and on-the-job training. Education and instruction belong to subtly different discourses, as do teaching and learning.

21. In the language of campus life, teaching is synonymous with teachers in their roles of lecturers or tutors who regularly face their students and teach them. Teachers see themselves as educators rather than instructors. They "teach" themselves as well as their subjects and, to the extent that this happens and the results are thought to be morally and/or socially desirable, impart education and not "mere instruction". Learning, on the other hand, is by no means coincident with teaching. Learning is a neutral concept. It refers to anything a person learns from whatever source -- whether as a result of teaching, instruction or self-instruction -- and includes misinformation, erroneous knowledge, dubious attitudes and values, as well as accurate information, attested knowledge and socially approved attitudes and values.

22. This intent of this report is not to set up either/or contrasts, but differences are to be detected in the preferences of face-to-face and distance teachers, as shown by the different emphases they give to the words "teaching" and "learning" when talking about their work. Different teaching roles give rise to different expectations and to different kinds of performance. Face-to-face teachers understandably equate effective learning with the effectiveness of their own teaching performance. Distance teachers equate it with the quality of the courses that they and their colleagues devise and the availability of support services for their students. The nature of their work forces them to make a distinction between what they want to teach and the ways by which it can be learnt.

23. This is where the information and communications technologies enter the discussion with their electronic networks and other "spellbinding" practical applications. These technologies break down barriers of distance, and they are becoming interactive. They could transform distance education. With a telephone,

a student's lecturer, tutor or instructor can be as near as his or her ear. By being part of a computer network, students can have direct access to data-bases and libraries. With CD-ROM they can have alternative access to similar sources. These innovations are taking the distance out of distance education.

24. They are also causing the age-old tension between knowledge and information to be discussed in a new context. Knowledge has a basis in information but in conventional discussions of education is often contrasted with it. A person knows something when he/she can transpose information for new, perhaps unique purposes, knows its limitations as well as its usefulness, can make judgments about it and, generally, can place information in an interpretive frame of reference. It is not easy to think about knowledge in isolation from the processes of thought to be used in acquiring it. Again, the direct, personal contact is usually thought to be a necessary condition for acquiring knowledge rather than "mere" information. Socrates still presides in the academy.

25. Here we are again speaking of an ideal, but the performance of lecturers and tutors often falls short of it. For all those who are outstanding in inducting students into forms of knowledge there are others whose contribution is much less distinguished. The question, then, is whether valued moments of insight and enlightenment must always depend on personal contact with good teachers. The answer is that it may no longer need to.

26. The best examples of study materials prepared for distance-learning will meet any criterion for the imparting of knowledge. They have come about because the men and women who have devised them have been as much concerned with the way students will most usefully form their understanding of the knowledge which they must somehow make part of themselves as with the content of the knowledge itself. Good distance courses are typically the result of co-operative effort among people who draw on two distinct forms of knowledge: knowledge of the subject and knowledge of the way the content of subjects can in any given circumstances be most usefully organised and presented for students to study by themselves with varying forms of assistance. Inspection of such study programmes shows that Socratic approaches -- where students are led into a subject by means of carefully framed questions which are intended to take them to its heart -- are standard practice. These approaches, it is important to note, have been developed during the last generation for distance education systems that have depended on low technology -- print, post, and local tutors -- rather than telephones, computers, modems and telecommunications. For at least the foreseeable future, the great bulk of distance-learning will continue to use low technology. But regardless of the means they employ, these approaches are properly thought of as technologies of distance-learning.

27. Such approaches are open to the criticism that, because students must often study in isolation, or because there are unavoidable delays in having assignments returned to them, teaching/learning relations cannot be as immediate and therefore as effective as they should be. Enlightenment can often require a student's urgent question to be answered when it is raised and that usually requires direct personal contact with a teacher or tutor, whether in person or by telephone.

28. New inventions are, however, making it possible for teachers and students to make immediate connections between information and the complex ideas we call knowledge. Experimental work in the educational applications of hypermedia has the potential to make students active participants in face-to-face teaching as well as in distance modes in ways never before possible. This they may well be able to do by asking questions through a personal computer while they are attending a lecture or working through a study unit somewhere else -- at the workplace perhaps -- or at home. Computers can provide anonymity that is not possible with the asking of questions in conventional lecture rooms. Comments and questions (especially questions that students are often too embarrassed to ask in class because they think that everyone

else knows the answer) could be logged by computer and analysed by the lecturer or the writer of the study unit. One of two things could then be done -- the lecture/study materials could be revised to clarify the point in question or, alternatively, answers could be provided, stored in the computer's memory, and made routinely available through a program's "help" function. The hope, in short, is that teacher learning programmes will be refined and improved in the course of time. The lecturer's answers to all the likely and, no doubt, many of the unlikely, questions that can be asked of the knowledge to be imparted will be written into the courseware and therefore into the teaching/learning programme. Students will have access to content that is better organised and presented and they will also be able to tap into well-honed "help" functions. Learning programs that can be accessed by computer at times and places of a student's choice have the potential to revolutionise access to teaching of the highest quality. And they would pose an important practical question. Once the teaching is distributed in a programme, will it be necessary to continue offering it in face-to-face settings?

29. Experimental work along these lines raises a fundamental question about the essential nature of what during the last generation has come to be known as distance education. It shifts our attention from the problems of distance to the concept of guided self-study, with implications for face-to-face teaching as well as distance-learning. It opens the possibility of nothing less than a paradigm shift in the way that post-secondary teachers conceive their role as teachers. Deeply ingrained attitudes are being challenged by new technological possibilities. Instead of thinking of part-time, extra-mural and distance students as disadvantaged, teachers must now consider the advantages that information and communication technology could offer *all* students, full-time and face-to-face no less than distance students. Instead of thinking of distance-education modes of teaching as second-best solutions, all teachers must become familiar with the pedagogic principles they express and then ask themselves how far these are or should become part of their personal stock in trade.

30. The rest of this report proceeds on the assumption that the educational significance of recent innovations in telecommunications lies in the possibilities they open up for guided self-instruction, with implications that are as important for learning on campuses as off them. Be it noted, however, that the emphasis is on "possibilities". The point cannot too often be stressed that teaching/learning courses of the highest quality are the essential requirement, however they are made available to students. Everything depends ultimately on the quality of the thinking that goes into devising courses and courseware, which means the creativity and skill of teachers as facilitators of other peoples' learning. Regardless of how they are presented, courses are only as good as the learning they can offer. If "junk" goes into a programme, only "junk" can come out.

Section 3: The Present Position

31. The OECD countries differ considerably in the use they have made so far of distance education and of information and communication technology in post-secondary education. Some can now draw on experience gained during several decades, some have entered the field during the last decade or two, while others still have to do so. Generally speaking, the main focus of policy until quite recently has been on finding ways of increasing access to undergraduate programmes. Developments in most countries in technical and further education and in continuing professional education have been slower. Within countries, too, there have been jurisdictional divisions: university, other forms of post-secondary education, and training within industry are usually handled by different agencies. The record is one of uneven

development, and most Member countries are now seeking to bring post-secondary education and training under policies that are more comprehensive and better articulated.

32. The main impetus towards the use of distance education for university students so far has come from governments acting on the recommendations of planning agencies or advisory bodies. Open universities and dual-mode universities are providing distance education because the government that funds them has requested, directed or permitted them to do so. It is the same with most, if not all, of the post-secondary institutions that provide distance education in trade, technician and other vocational courses for recognised qualifications. Policy and funding decisions reside in governments or other public agencies, but the position is very different in the field of training within industry. There, the initiatives have come primarily from enterprises acting on their own behalf or from enterprises acting in association with government agencies, often with public subsidy.

33. At the institutional level, too, there is an interesting range of experience in the different countries. Open universities are the preferred mode in several European countries and in Japan. Other European countries, such as France, Sweden and Norway, have added distance-education programmes to face-to-face universities, making them to some extent dual-mode institutions. In Australia, Canada, New Zealand and the United States, where part-time and off-campus students have traditionally been a significant part of enrolments, various universities and other post-secondary providers have responded with distance education programmes and have become, in varying degrees, dual-mode institutions. Canada has open institutions as well. There, education is a provincial responsibility and different provinces have different policies. Quebec and Alberta have open universities. British Columbia has an open learning agency as well as dual-mode universities.

34. It is as well to record that, for most if not all OECD countries, a great deal of educational politics lies concealed behind this bland summary. Though they have since justified themselves, the first open universities were set up in the face of scepticism and opposition from the guardians of face-to-face university education[4]. And in countries where dual-mode universities have become the policy response, few of the older established universities have introduced distance-education programmes. Academic life for the vast majority of university teachers has remained centred on the teaching of face-to-face students on campus. Distance education programmes have been seen as peripheral to their real work, part of the university's public service role.

35. For various reasons, then, distance education is usually thought of in contrast with conventional face-to-face teaching. It is now entrenched in purpose-built, distance-education institutions and is supported by growing numbers of teachers who identify themselves as distance educators and are members of professional organisations dedicated to advancing the cause of distance-learning. Much of the writing about distance education concerns demonstrating that it is what Desmond Keegan calls "a coherent and distinct field of education endeavour"[5].

36. Distance-learning is often discussed as if it were synonymous with open learning, but the two phrases are not interchangeable. Open learning summarises a philosophy of education. It advocates the removal of barriers to formal education that have arisen in the organisational, administrative and teaching practices of conventional institutions whose internal cultures have been shaped by face-to-face teaching of full-time students. Distance education is an important way of achieving open education but is not synonymous with it. Flexibility and choice are two main indicators of openness. They show in an institution's admissions policies; in the content of its courses and the way they are organised, in the place or places where they will be made available; in the media of instruction and/or the timing of delivery; in

the choices available to students to switch modes or mix them; in the pace at which students are allowed to proceed; in the forms of support available to them and the types of assessment that are used. Open universities have such policies but, to some extent, so do many face-to-face universities. Indeed, post-secondary institutions are best thought of as having a place on a spectrum that ranges all the way from extreme openness to extreme conventionality, with many shades of difference between.

37. Distance education is best thought of in terms of its processes. Many distance-education programmes are open in the sense that they have accommodating admission policies, but this is not essential to the concept of distance education. It is worth noting here that the recent European Commission report speaks of "open distance-learning". This conveys two important meanings. It acknowledges by implication that distance education is a subset of open education. It is also a reminder that, in the wider context of post-secondary education, most of which is conducted in face-to-face institutions, distance-learning approaches will not, of themselves, be enough to ensure that open education is as open as it must become in the future. The gatekeepers of face-to-face learning in many institutions have so far withheld recognition from qualifications obtained through open universities and other distance modes, and this inhibits the transfer of students from distance- to face-to-face modes and vice versa. Under policies of open distance-education, the mutual recognition of qualifications is a key issue and, with it, the harmonisation of degree and diploma structures.

38. The impression that distance- and face-to-face modes of learning are separate, parallel educational enterprises has become fairly widespread during the last decades. With this has emerged a tendency to act as if policies that hold promise for one mode are without relevance to the other mode. Two important recent policy documents reflect that tendency. In November 1991 the Commission on Open and Distance Higher Education in the European Community published a comprehensive report[6] which charts lines of development in what it refers to as open distance-learning in post-secondary education and training in the countries of the European Community. As would be expected, a report on open and distance education deals exhaustively with that subject. But it would seem to be evidence of a state of mind that the only cross references to face-to-face institutions refer to the mutual recognition of degrees and qualifications and to the need to standardise degree formats and requirements. There is no discussion of the potential for teachers in face-to-face institutions of the best practice of teachers whose experience is being gained in distance-learning. The same comment can be made about the report of the Commission of Inquiry on Canadian University Education[7]. Distance education gets a useful chapter to itself but again, apart from a reference to the problems distance students have in getting credit transfers to face-to-face universities, there is no discussion of the wider pedagogic significance of the best work in distance teaching and learning.

39. The CERI study on the Impact of Imformation and Communication Technologies on Post-Secondary Education thus offers an opportunity to examine possibilities that seem not to have been brought into focus as yet[8]. The question that stands behind this project is not what distance- and face-to-face modes have to offer each other but how both can benefit from the creative educational use of the information and communication technologies that are now available or soon will be. Always, however, in discussions of educational policy there are blind alleys to be avoided. It is essential, therefore, to be clear what the discussion is about before positions are taken on how answers might be administered. This requires us first to unpack the meanings that have come to be associated with "distance" in the phrase "distance education". Distance education is not to be equated with the various means by which courses for guided independent study may be delivered to students. The essence of distance-learning courses is that they have been conceived, devised and produced to support guided self-instruction. The men and women who devise them begin with students and with what they can be expected to bring to a course of study, as well as with bodies of knowledge and any difficulties there may be in "teaching" them "at a distance", and they employ

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principles of learning to guide students through the courses they develop. Discussions of educational policy should, accordingly, focus on the knowledge and expertise, the forms of organisation, the infrastructures and the funding arrangements that post-secondary institutions must have if they are to produce courses of good quality that students who opt for self-study modes of enrolment can then use effectively. These are not questions for information and communications technologists to answer; they are educational questions in search of pedagogical answers. Delivery systems are important, but they are secondary considerations.

40. Within that policy context, new means are now becoming available to give effect to educational objectives. In the 1990s, governments and institutions have been using a wider range of policy instruments than they did a decade and more ago. Among other things, some are making more use of private sector approaches to public responsibilities. For instance, the notion of the strategic alliance is becoming important to post-secondary institutions that are positioning themselves to take advantages of distance-education approaches. To the expert knowledge they already command through their own teachers, they must add knowledge of distance-learning approaches and the expertise required for its effective conduct, and they must also gain access to suitable electronic infrastructures and equipment. One way of doing this is to create consortia of complementary interests. Some examples are given later in this report.

41. By no means all the initiatives are being taken by education institutions or by other agencies that are usually thought of as public sector agencies. Many private sector companies have developed in-house education and training programmes to the point where they have sophisticated training packages that they are marketing. Public agencies and private sector companies are also putting education and training programmes out to tender. They define their requirements and then use open or selective tendering processes to find what they consider to be the best provider. So far this approach has been used more for training than for educational programmes, but there is no reason in principle why that should remain so.

42. These approaches are blurring the distinction between private and public sectors in post-secondary education. And because public sector funding agencies are also beginning to use private sector policy instruments, publicly funded institutions are being forced to compete with each other as well as with private providers. Many of the occupational groups in relation to whom these approaches are being used can be well served by distance-learning or self-study approaches, and the implications for the future of distance education are thus very considerable. But their potential application is by no means confined to that sector.

Section 4: Distance Education: Review and Prospect

43. It is important to remember the pedigree of most distance-education enterprises. They are heirs to the mechanics institutes, circulating libraries, correspondence schools, evening classes, folk high schools, summer schools, extra-mural educational services and many others that have their origins in the 19th century. Their common aim has been to spread enlightenment, knowledge and instruction to men and women who, usually for lack of money and the necessary formal qualifications, would otherwise be prevented from studying for higher educational awards. They serve important social as well as personal objectives, both of which have come to have increasing importance to national governments during the second half of the 20th century. Human resource development has become an economic and thus a political imperative.

44. Most initiatives in distance education during the last quarter of a century have sought to increase

opportunities for undergraduate study. However, much more attention is now being given to the non-university sectors of post-secondary education, as arguments based on equity are reinforced by considerations of economic efficiency. Both call for greater national investment in the continuing education and training of much larger percentages of the adult population than would have been thought necessary on economic grounds a decade or so ago.

45. In all OECD countries there are large numbers of men and women who already hold graduate and other professional awards and whose livelihoods require them to keep abreast of advances in knowledge in their field. During the last generation they have been an increasing source of demand on universities and other post-secondary institutions for programmes of postgraduate study and professional continuing education. They will make even greater demands in future. Professionals, who are better able than the underprivileged to pay for their continuing education, are acutely aware of the consequences for their own livelihood of not keeping up to date. Increasingly, too, they are having to interpret their professional expertise in new and changing contexts. There are, for example, questions of accountability and degrees of responsibility in cross-disciplinary projects, environmental impacts to be considered, and various ethical considerations to be aware of in activities where statutory obligations and human rights issues converge. Given, too, the sophisticated nature of the sites where professionals typically work, information and communication technologies are already significant features of their working environment. Engineers, doctors, nurses, accountants, lawyers, teachers and managers and administrators in many countries, to mention only obvious examples, are finding that for some aspects of their professional refreshment or further study after graduation they are participating in electronic classrooms. They do this by remaining on their work site or moving to a nearby site where they can take part in telephone conferences or video conferences or computerised learning programmes.

46. Professional groups are important for another reason. They involve university teachers in professional schools who would otherwise not expect to become engaged in distance education, they do so at the postgraduate level, and they are very likely to use advanced distance-education technologies. Teachers involved in such programmes can thus find themselves at the cutting edge not only in what they are teaching their fellow professionals in the field, but in the technologies they use to do so. Such developments will make institutions of post-secondary education much more open to potential students in future than they have been in the past.

Section 5: Face-to-Face Teaching: Some Problems

47. Two problems are regularly raised in discussions of teaching and learning in face-to-face institutions of post-secondary education. It is worth noting, however, that both were matters for serious discussion before distance-education approaches offered alternatives and long before the most recent possibilities associated with information and communication technology. The first has to do with the well-documented inefficiencies of lectures as a main mode of undergraduate teaching, the second with the problematic status of teaching as a function of post-secondary institutions, particularly universities. Most university teachers in OECD countries would recognise a point made in the Report of the Commission of Inquiry on Canadian University Education. After noting that in some ways Canada was more innovative than other countries (in the use of co-operative education and distance education, for example), the report stated:

> "Still it is a general feature of universities that, the vast majority of the time, a person is standing in front of a room of students and lecturing to them. In this respect, things have not changed in a century or more. Given the inventive, creative minds that constitute university faculties, the Commission has to ask why it is that those minds rarely apply themselves to creating changes in their own industry as revolutionary as those they instigate in most other sectors of the economy[9]".

48. As the Report records, there are creative lecturers who do give their minds to making their lectures into effective learning experiences for students. They stimulate interest by posing questions of the material they are expounding, use audio and visual aids to amplify their points, place topics in various contexts to illustrate their significance, draw attention to alternative interpretations and matters that may be in dispute, and suggest lines of inquiry for students to follow up themselves. Nevertheless, the general criticism still stands. Lectures, particularly to large numbers, are essentially one-way transmissions; it is of their nature that students have few opportunities, if any, to ask a question, seek a clarification or make a comment. And, as transmissions, they are often inefficient; explanations are not always coherent or clearly stated; students mishear or misunderstand what they hear, miss some points while they are writing others down, have lapses of concentration and can be distracted by others. These deficiencies can be repaired in tutorials, laboratory sessions, through the use of study guides, and by lecturers who are accessible to students in search of clarification. But the central question remains: for many, perhaps most, of the purposes served by lectures, are there more effective ways of facilitating learning?

49. On the status of teaching in universities, the recent Canadian Commission recorded comments that also go to the heart of the matter: "The problem is that, when dozens of witnesses spoke of research 'opportunities' and teaching 'loads', they were unconsciously telling us that research and teaching have already been set apart from one another. The question is one of balance". Certainly the words "opportunities" and "loads" signaled very different attitudes to research and teaching as functions of university teachers. Similar comments from review bodies and from influential university leaders could be quoted from most if not all OECD countries. There is a widespread view that excellent teaching ought to be given greater practical recognition in the inner life of universities, as is evidenced by their rewards structures and the signs of prestige and esteem they give their most distinguished members. Also widespread is the view that, for this to happen, the competing claims of research and teaching must be redressed.

50. In the context of this report, two comments can be made. Particularly in countries where they depend heavily on public funding, universities are unlikely to be able to rework the trade-offs between research and teaching as if they were solely for their own untrammeled decision. They face the twin spectres of more students and of tighter funding regimes. What Japan, the United States, Canada and Norway have achieved -- a quarter or more of each age cohort graduating -- other OECD countries are now setting themselves as targets as they commit themselves to policies of mass post-secondary education. But all countries are experiencing funding limitations. Their governments have a heightened concern for the efficient use of scarce resources and value for money from what cannot avoid being the most expensive sector of national education systems. The quality of teaching and learning, how to improve it, and how to make it available to a larger, more diverse student population is thus an essential part of the policy agenda for face-to-face as well as teaching institutions. One of the questions being asked is how far excellent face-to-face teaching and excellent distance-learning derive from the same pedagogical principles even though they might employ them differently. Another question is how far excellent teaching and learning in both modes can be supported, enhanced and made more effective (in both the educational and economic sense) through the judicious use of information and communication technology.

Section 6: The Matter of Modes

51. Many teachers in post-secondary institutions are surprised to discover that they are teaching in what some of their other colleagues refer to as a dual-mode institution. They may have known that their institution was also engaged in the teaching of distance-education programmes but that did not signify any change in the character of the institution itself. Dual-mode is a term which includes distance educators, who are a new breed in what, before their advent, was solely or predominantly a face-to-face teaching institution. As used by distance educators, dual-mode is both a marker and a reminder. It marks them off from distance educators who are working in single-mode distance-education institutions such as open universities, open polytechnics, open-learning agencies and open colleges. It reminds their colleagues that face-to-face teaching and distance teaching ought to be thought of as different modes of teaching and learning, each with its own distinctive requirements. Therefore, for those likely to favour its use, dual-mode serves purposes of advocacy as well as description. During the last generation the advocacy has been necessary and important. It is difficult to think of a country where advocates of open or distance-learning have not encountered resistance. Institutional indifference or inertia has often been stifling.

52. In countries where it is part of the provision of post-secondary education, therefore, distance education is found in one of two types of institution: an open university, polytechnic or college which enrols only distance students or a dual-mode university, polytechnic or college that teaches face-to-face as well as distance students[10]. In the latter instance, distance students are usually outnumbered, often significantly, by face-to-face students, nor will all faculties, schools or departments be teaching distance students. Both institutional approaches have strengths and weaknesses. The great strength of the open institutions is their ability to concentrate single-mindedly on teaching effectively at a distance. Here the United Kingdom Open University has become an international flagship. It has demonstrated not only that university teaching and learning of the highest quality can be conducted at a distance but that it can be innovative and creative in ways that can be of benefit to face-to-face universities as well[11]. During the last 20 years it has become a model for open universities in many countries.

53. The model has its limitations, however, as the very high quality of learning materials and supporting services depends on large populations of unmet demand for undergraduate qualifications. Where their admission policies are driven by arguments based on economics of scale, open institutions can find themselves prevented from responding to demands for distant study programmes when numbers are comparatively small. There can be problems, too, in having their awards and degrees accepted by other post-secondary institutions. There have been endless questions of equivalence to be resolved: whether open-university standards and degree structures are comparable with those of face-to-face universities, whether their awards will be recognised as prerequisites for postgraduate study, and whether partially completed degrees will be accepted for cross-crediting by face-to-face universities to which open-university students may wish to transfer.

54. The high profile of open universities nationally and internationally has tended to obscure the distinctive contribution of dual-mode universities. It would not be too much to say that the impression has gained ground that single-purpose, open universities are the preferred way of offering distance education. But there have been good reasons why dual-mode institutions have been developed in some countries as

their preferred approach. Systems and institutions that already have flexible admission policies do not have large backlogs of unmet need that can be quantified and used as an argument for creating new "open" institutions dedicated only to satisfying their educational aspirations. Educationalists, administrators and politicians have not always been persuaded that, in the long run, separate provision is desirable. And within systems and institutions with long traditions of providing equality of educational opportunity, there have been positive reasons for preferring a dual-mode approach. The dual-mode institutions in Australia, Canada and New Zealand are all heir to that tradition. Their work in distance education grew out of earlier policies for extra-mural study and part-time student status and is directed by the conviction that extension and continuing education programmes for the wider community are part of their institutional mission.

55. As providers of distance education, dual-mode institutions have their own characteristic advantages and disadvantages. It is clearly an advantage to men and women who have the right to enrol as an extra-mural or part-time student to be able to have access to the study materials, tutoring arrangements and other services associated with distance teaching and learning. It is an advantage when lecturers who teach face-to-face courses are also actively engaged in developing teaching and assessing distance courses in their field. The professional development associated with the preparation and delivery of distance programmes is often referred to as a benefit by such teachers, who say that it has served to improve the quality of their face-to-face teaching. Arrangements for students to transfer their enrolment from one teaching mode and to have credits recognised by other institutions are also easier in some systems.

56. The main disadvantages lie within the institutions themselves. In many cases, distance-education offerings have grown very rapidly from small beginnings to large enrolments. Policies have developed ad hoc and the conditions under which they are administered and taught place those who are heavily engaged in them at what they perceive to be disadvantages. Moreover, however it is organised, distance education makes very different demands on institutional planning, budgeting, facilities, organisation and management. Institutions whose ethos has been shaped by face-to-face teaching have had difficulty in providing adequately for the different requirements of distance-teaching modes.

57. Nevertheless, the possibilities either of being or becoming dual-mode have recently been claiming much more attention, partly as a result of institutions considering their options as providers of continuing professional education at a time when innovations in telecommunications are making interactive learning at a distance a realistic possibility. It is also a response to projected increases in enrolments in prevailing climates of uncertainty about future funding regimes and an entrepreneurial response to market possibilities, for off-campus offerings in management education which are, in particular, associated again with telecommunications technology.

58. But there is another and more pervasive reason. In the rapidly changing circumstances of the present time, the advantages that were earlier thought to be with single-mode distance institutions are being challenged. Where, a generation ago, post-secondary education was in most OECD countries thought of as a public good to be provided largely at public expense, it is now being viewed in a very different light. The image today is of private goods that could be supplied from many sources, some of them subsidised by public money, to students who will be expected to bear an increasing portion of the costs themselves. If competitive markets is what the future holds, single-mode distance institutions will not necessarily have a competitive advantage. Their great strength, of course, is the operational knowledge they have amassed as providers of distance education; but it is public knowledge and can be appropriated by others. More to the point, Greville Rumble's article, "The Competitive Vulnerability of Distance Teaching Universities"[12], presents a financial analysis which draws attention to advantages that may lie with dual-mode universities (or with face-to-face universities that may decide to become dual-mode) compared to those of open

universities. They already offer a wider range of degrees and qualifications than rival open universities, could diversify at less cost, would not necessarily have to rely on large numbers of enrolments to be viable as providers of distance programmes, and could offer a wider range of options to potential students. They would be able to shift the emphasis from one mode to the other, depending on changes in the pattern of demand for particular courses. If they were to work together co-operatively as consortia, dual-mode universities could well become very competitive indeed in their distance offerings. Rumble ends his analysis with the provocative suggestion that, in a competitive environment, a distance university's most effective response may well be to become dual-mode by spawning a campus or through a merger with a face-to-face university. As will be mentioned later, however, formal mergers are not the only response available.

Section 7: Modes or Mixes?

59. A difficulty with distinctions is that they become hardened through reiteration. But in a fast-changing world, the conditions that caused the distinction to be made may have changed, raising the question whether it remains valid. Twenty years ago the distinctions between distance- and face-to-face teaching were sharper than they are now. Under typical arrangements, distance teachers and their students were separated in time and space. They kept in touch with each other through printed study guides and comments on assigned work. Efficient postal services were essential to effective distance education. Some distance educators held, as a matter of professional doctrine, that distance-learning materials should be devised so skillfully that students would be able to work through them effectively without further interaction with a teacher. This made a pedagogical virtue of necessity. Where students were cut off from their teachers, their only interaction was indeed with their study materials.

60. Distance students no longer need be so isolated. Providers of distance education have broadened the basis of their operations. Students signing up for courses can expect to have their study materials supplemented in ways which may include local tutoring, workshops or short periods of concentrated teaching on a campus or at a study centre, teletutorials and regular telephone calls to their tutor, and perhaps the opportunity to take part in teletutorials. The mode is distance, and the students are off campus, but there is regular interaction with tutors or teachers and, for many, there will be some face-to-face teaching as well.

61. During the last 20 years, too, a great deal of effort has been dedicated to the improvement of teaching on campuses for students in the face-to-face mode. For the most part, the assumption remains that teachers teach through personal contact with their students in lectures, tutorials and seminars, and individually in response to questions raised by students. The aim is to improve the quality of teaching and learning without changing the essential character of face-to-face teaching. Some initiatives, however, have been more radical. The approach to undergraduate medical education pioneered by Western Reserve University, Ohio, in 1948 and taken up in some other medical schools, shifts the focus from teaching to learning. Under "problem-based learning", teachers become an expert resource, devising and organising the courses of study, posing the questions their students are to wrestle with, identifying the texts and resources to be used, acting as guides and facilitators and monitoring and assessing progress. Approaches to learning that foster co-operation among students rather than competition between them have also been pioneered, particularly in the United States and Canada. Assisted as they can be now by computer-assisted learning, face-to-face students can be given greater control over their own learning. Computers, modems,

telephones, servers and fibre optics are opening up new possibilities for campus teaching as they are for distance-learning.

62. These developments have an important bearing on the policy issues we are dealing with here. Processes and approaches that have come to be associated with distance-learning are by no means confined to it, nor should they be. Indeed, the phrase "distance-learning" is coming to be used unambiguously only in its administrative sense, with reference to a category of students, for the purposes of enrolment statistics.

63. Even as an administrative category, however, distance students are not a distinct set. As institutions become more flexible in the ways they offer study programmes, so do students living in urban centres find that they can mix and match courses. Murdoch University in Western Australia, for example, allows students to choose between face-to-face and distance forms of teaching for the courses they enrol. Some choose one mode or the other, others put together degrees that are a mixture of both. Where, as is happening in many countries, the costs of tuition borne by students is increasing, this fact of choice has important implications for the future. It gives a degree of consumer sovereignty that students have not been allowed to exercise in the past, and it has become a significant influence on enrolment patterns and on the demand for one form of delivery rather than another. It also begins to create a market in which institutions as well as modes of delivery are in competition.

64. By the turn of the century, advances in information technology could well have the potential to transform teaching/learning relationships for students, whether they are studying on or off campus. The technical possibilities of multi-media and hypermedia are bringing together under one umbrella a number of strands of developments that, until recently, have been pursued separately -- software for computer presentation, media corners, computer-assisted instruction, distance-learning, computer conferencing systems and computer-assisted co-operative learning. Teachers could be "in" computerised teaching programmes and their associated databases and help functions and accessible from wherever a student, a computer, modem and a telephone wire could be linked to wider electronic networks. There have been many false dawns in the past as educationists have overestimated the educational benefits of technological innovation and underestimated the practical impediments to its widespread use. But information technology has the potential to transform learning as we have known it in post-secondary institutions. For that to happen, of course, the facility of the hardware must be matched by the quality of the software to be fed into it. And it is here that educational leaders in post-secondary education are better placed than at any previous time to prescribe the educational purposes to be served. The common feature of the trends we are concerned about here -- whether they arise from distance-learning, resource-based teaching or computer-assisted instruction -- is the emphasis on students as active learners who are studying in their own time and to some extent controlling their own learning. The challenge to educationists is to devise pedagogies of learning that will set the educational parameters within which the information and communication technologies will make their contributions to students' learning.

Section 8: A Pedagogy of Learning

65. Some may think it ambiguous to talk about a pedagogy of learning. Pedagogy is usually associated with teachers and lecturers and what they do to facilitate learning by their students. But in its generalised meaning, pedagogy refers as well to instruction, discipline, training and knowledge and to

principles applying to them. The discussion that follows shifts the spotlight from teachers teaching to students learning, regarding students as active agents in their own learning and teachers as active facilitators of that learning.

66. It should perhaps be emphasized, too, that learning as used here is not to be thought of in any narrow sense. A change in pedagogic emphasis does not imply any change in the aims of post-secondary education. Those aims are variously phrased but they usually require students to:

- -- broaden and deepen their knowledge of facts, concepts, theories, skills, principles, values and issues;
- -- develop the generic cognitive skills of thinking, reflection, critical analysis, application, integration, problem-solving;
- -- develop general strategies for finding answers to questions and solving problems and to develop research skills appropriate to their field(s) of study;
- -- develop personal qualities of self-esteem and initiative and the ability to take responsibility for their own learning;
- -- acquire (as appropriate) vocational information, competencies and values;
- -- develop personal values which will include ethical standards, awareness and tolerance of other viewpoints, appreciation of their own sense of identity that of others, appreciation of the values and the value conflicts of their society, and respect for the environment.

67. In achieving these aims students must develop:

- -- communication skills: reading, listening, writing, presenting;
- -- number skills: performing basic operations, tabulating and interpreting data, using statistical operations appropriate to their discipline or field;
- -- literacy in information technology: knowing how to find out, using databases, computers and other technologies[13].

68. Some other things can also be taken for granted. Students differ greatly in their personal backgrounds, including how much they have to spend on their further education, previous learning, motivation and the confidence with which they approach new learning tasks. They differ, too, in the institutional resources they can use in the course of their learning: libraries, books and computers, bibliographical networks, laboratories, teachers, other students, relevant life and/or work experiences. And they differ, too, in the learning strategies available to them and the ones they use: lectures, tutorials, learning contracts, syndicates, participant observation, action research, internships, arrangements for co-operative learning, self-directed study, resource-based learning. Whatever the range of possibilities, however, the essential task for students is to make the best use of the resources available to them for their own learning. And increasingly, given the range of resources in post-secondary institutions and the different backgrounds and circumstances of student enrolments, teachers are required to see themselves less as imparters of knowledge and more as sophisticated designers of resources and as facilitators and managers of their students' learning.

69. A great deal is known about what makes for effective learning, which can be reduced to eight working principles of very wide applicability[14].

Well devised courses are essential to effective learning

70. The most important decision that many prospective students will make is whether to enrol for a particular course. They will want to know what they can bring to it from their previous learning, the nature of its cognitive and other demands, the level at which they will be pitched and some idea of the kind of performance expected of them. They should be able to try themselves out on exemplar material that introduces them to the academic content of a course and requires them to employ thinking and/or practical skills associated with it.

71. Courses of study vary greatly but they have one thing in common -- they are intended to encapsulate some body of knowledge or form of experience that students will be expected to deal with satisfactorily through sustained personal application. Most courses take shape in a teacher's mind before they are taught and have a life that is independent of the students who sign up for them. Some emerge from discussion between a lecturer and his/her students. Regardless, however, of such differences, students should know what they should do by way of personal preparation before a course begins.

72. Course statements should be available well before a course begins. They should provide the aims of a course, an outline of its content and how it will be developed, an annotated reading list, some idea of the issues it will explore, the tasks students will be required to do, the forms of assessment to be used, and the criteria that will be applied to recognise the successful completion of the course. These are essential prerequisites of good teaching and effective learning.

73. Technological resources can be used to enable students to preview the requirements of a course and pre-test themselves on exercises designed to gauge their responses according to the criteria of satisfactory performance.

Good practice encourages student/teacher contact

74. Frequent communication between students and teachers is the most important factor in motivating learners and keeping them involved. The active interest of their teachers helps students get through difficult patches and keep on working. By getting to know some of their teachers well, students can reflect on their own values and think about their future plans, and provide comments about their courses of study for lecturers to consider.

75. Technological resources that increase access to teachers, help them to share useful resources for learning, and provide for joint problem-solving and shared learning, can increase communication between students and teachers. By offering neutral sources of information and guidance, they can assist students who are shy or reluctant to put questions to a teacher or who may be experiencing difficulties with a particular teacher.

Good practice encourages active learning

76. Learning is not a spectator sport. Students do not learn much by listening to lecturers, memorising set pieces and reproducing answers. They must talk about what they are learning, write about it, relate it to their experience and that of others and apply it to their daily lives. Students also need to know whether they are on the right track and how well they are progressing.

77. It is a prime function of good teachers to facilitate active learning. But technological resources that give access to data relevant to real problems and which provide, in the form of interactive exercises, different points of view to be reconciled or explained can strengthen active learning.

Good practice encourages co-operation among students

78. Working with others often increases each person's involvement in learning. Sharing one's own ideas and responding to the ideas of others improves thinking and deepens understanding. Learning can be enhanced by being a team effort rather than a collection of solo performances. The social values to be learnt through collaborative effort cannot be learnt through competitive learning undertaken on one's own.

79. As time goes on, technological resources such as telephones, e-mail and computer networks can be expected to increase the scope for interaction among learners and for collaborative problem-solving projects.

Good practice gives prompt feedback

80. Knowing what one does and does not know, what one has mastered and still has to master, can become a focus for further learning. Students must therefore have regular feedback on their performance. At the beginning of a course they need to know how far, if at all, their previous learning relates to the knowledge and skills they are setting out to master. They need frequent opportunities to perform in ways that relate to the objectives of the courses they are studying and to receive suggestions about ways they can improve. There should be regular opportunities for them to reflect on what they have learnt, what they still need to know and how they should go about it in the time available to them.

81. Technological resources can greatly increase timely feedback if they are programmed with clear criteria for evaluation to enable students to apply those criteria to their own self-evaluation, and if they provide frequent opportunities for them to try themselves out and thus monitor and assess their own progress.

Good practice emphasizes time on task

82. There is no substitute for the amount of time actually spent on the tasks to be accomplished. Using time effectively is critical for students and teachers alike. This requires teachers to set realistic assignments and for students to work to regular study schedules and learn how to manage that time effectively.

83. Technological resources can improve the quality of learning by increasing the amount of time students are "on task". They can do this by giving students ready access to the learning resources they must use, facilitating efficient communication between students and their teachers and among each other and prescribing clearly defined cycles of performance and evaluation.

Good practice communicates high expectations

84. Expecting students to perform well becomes a self-fulfilling prophecy when teachers and institutions hold high expectations for themselves. Students must therefore be able to get clear information about the goals their teachers have for their courses. They should be encouraged to set their own goals, think about the things they most want to learn in the course, and how they can make the best use of the resources available to them while following it. They should be encouraged to do extra reading, writing and independent exploration to reach their learning goals. They should be conscious of the trade-offs between what they want to learn and getting their best grade for each course.

85. Technological resources which are programmed to challenge students with sophisticated concepts, complex problems and high-level thinking skills in their field of study, which communicate clear, demanding criteria for performance, and which facilitate interactive dialogue, can set high expectations for teachers and students.

Good practice respects diverse talents and ways of learning

86. There are many roads to learning. People differ in their talents and styles. Brilliant students in a seminar may be "all thumbs" in the laboratory, art studio or at the drafting table. Those rich in hands-on experience may not do so well at theory. All need opportunities to learn in ways that work for them and they also need to be guided into less easy ways.

87. Technological resources that exemplify different methods of learning through powerful visuals, well-organised print, direct experience, tasks requiring analysis, synthesis and evaluation, with applications to real-life situations, can help students learn in ways they find most effective and broaden their learning repertoire.

88. These eight principles indicated earlier are presented as principles to be applied wherever organised learning is planned and managed in post-secondary education. They are as relevant to teaching and learning in face-to-face institutions as they are in distance institutions. They contain no surprises for teachers in face-to-face institutions who use problem-based learning approaches, resource-based learning or co-operative learning in their work with students. They are guidelines in relation to which the best distance-learning programmes are developed and delivered. They are the principles advocated wherever post-secondary institutions have teacher or faculty development units and staff with the responsibility of working alongside their colleagues to improve the quality of teaching and learning.

89. The information and communication technologies that are coming into use have a remarkable and, as yet, largely unrealised potential to apply principles of good practice to post-secondary education. We already know that they can:

- increase the access students have to information;
- increase interaction among students and between students and teachers;
- strengthen student motivation;
- increase students' time on tasks;

-- increase the scope for students to initiate and have more control over their own learning;

-- increase the scope for inclusion of affective features of learning experiences;

-- increase the responsiveness of teachers and institutions to individual differences among students;

-- increase student contribution to the solving of real life problems.

90. There is, of course, a basic precondition; The technology must be easy to use, readily available where and when required, and affordable. As always, price will limit availability and use.

91. Wherever teachers and institutions are seeking to apply principles of good practice and are also harnessing the emerging information and communication technologies, they are making fundamental changes to time-honoured practice. Traditional assumptions and conventions about the where, when and how of teaching and learning are becoming obsolete. Differences between face-to-face or campus-based learning and distance-learning begin to break down when discussion focuses on underlying pedagogical principles. The critical factor is not where students are located but whether they can interact with a teacher or a teaching programme. Traditional roles and relationships for students and teachers become substantially modified. There is also a loss of monopoly. Teaching that is available to students is no longer confined to their having personal access to teachers, libraries, laboratories and other students on a teaching campus.

Section 9: Opportunities and Threats

92. Teachers who are committed to improving the quality of their students' learning are encouraged to do so by the opportunities that are opening up through the use of telephones, computers, electronic networks and CD-ROM. But those for whom all this is still outside their personal experience can be full of foreboding. Those, in particular, whose teaching experience has been shaped by the values of face-to-face universities frequently express their concern that a thoroughgoing harnessing of technology will mean the end of university education as they have known it. Higher education, many argue, is not to be equated with formal learning, grade point averages, and the successful completion of degrees, diplomas and other vocational qualifications. Some of the most important values of a university education are implicit in the experience itself -- they depend on the direct personal interaction of teachers and students and the students with each other, and they cannot be packaged or mass-produced through computer software, and accessed by electronic means. What sceptics need to remember, however, is that what may be called the civilising mission of a university education has for five centuries been as much the result of students' encounters with great minds through books, frequently mediated of course by their lecturers, as it has been the result of the direct personal influence of their lecturers and fellow students. Information and communication technologies are now making it possible for great minds and good teachers to become part of the learning experience of students in ways that have never been possible until recently. As with all good teaching, it is the quality of what goes into the programme that is all-important.

93. And books, which -- along with lecturers and tutors -- are at the heart of traditional face-to-face teaching are also being transformed by the new technologies. It is becoming easier to update a computer disk than it is to publish a new edition of a standard text. Increasingly, in the future, the information to

be found in encyclopaedias, atlases, economic and social surveys, yearbooks and other compendia whose current factual information changes from month to month and year to year, will be stored in computers as well as published in books. For everyone engaged in learning, computers and modems are becoming as important as book shops and library cards.

94. Nor does the notion of civilised values have the same resonance of even a decade ago. Societies that acknowledge themselves to be culturally diverse are also acknowledging that civilised values can mean different things in different cultural settings. Post-secondary institutions are recognising that, as their student populations become more diverse in age and cultural background, increasing numbers are coming from outside the cultural mainstream, while others have already formed their essential value allegiances before they enrol as students. The recurring emphasis in the practice of teachers in many countries is on the procedural and instrumental values associated with their discipline or field of knowledge. What post-secondary institutions typically now offer are perspectives, interpretations, case studies and studies of critical moments which students will find illuminating and which will train them to make sense of the important aspects of life in what they regard as the real world. Students are inducted into the assumptions, values and working procedures of particular forms of knowledge which they then use as map and navigating instruments to see what kind of sense that form of knowledge makes of the world they live in. Much of the best of this kind of teaching is interdisciplinary and is conducted by teachers working co-operatively. Distance-education approaches have shown themselves to be particularly effective in presenting the various perspectives as well as the expert knowledge that must go into the content of such courses, the study guides to accompany them, and the tutoring they must support.

95. The question now is whether these approaches should be used much more widely for campus students as well. Instead of seeing themselves primarily as lecturers whose main workplace is a lecture room, lecturers would see themselves as originators of learning materials which, under their guidance, their students would work through, undertaking assignments as required. Lecturers would work closely with colleagues expert in the practical application of principles of good practice to students' learning and with others expert in media, communications technology and publications. They would give fewer lectures, and the lectures would be recorded so that students had a permanent (as well as accurate) record, and so that they themselves could reflect on ways they might be modified or further improved for future use. Because students would have independent access to key texts and to questions posed in study guides, lectures would be interpretive rather than merely convey knowledge and information. For the most part, however, the interpretations and commentaries that once formed the core of their lectures would be included in the learning packages they devised -- some as written directions, some as questions to be thought about in relation to selected texts, others as strategically placed oral comments. Computerised multi-media will, in time, make it possible for these and other techniques to be incorporated in disks that students can use in their own time.

96. Lecturers will have the opportunity, too, to close the gap that frequently exists between statements of course objectives, with their listings of the tasks assigned to students and each student's interpretation of those requirements and their performance in relation to them. Teachers in face-to-face institutions have much to learn from distance teachers who regard it as an essential part of their responsibility to guide their students towards the learning outcomes they have set for them. The best of these study guides, taken in conjunction with the study materials they support, are good examples of principles of good practice in distance modes. Study packages produced by the United Kingdom Open University, for example, not only set standards for other distance education providers but influence the way teachers in face-to-face universities think about presenting their own courses and engaging their students in the intellectual disciplines inherent in their content. Indeed, one of the great merits of distance-education materials is that

they are in the public domain in ways that the methods of face-to-face teachers typically are not. Distance-education materials are available for scrutiny by academic peers, who can learn from them, criticise and adapt them or, using them as a starting point, improve them for their own teaching purposes. And it is that public character, more than perhaps any other feature of distance education, that holds the greatest promise for the pedagogy of learning in institutions of post-secondary education, whatever their mode or modes of teaching.

97. The public, or potentially public, nature of this information has a wider significance as well. Educational institutions are for various reasons becoming more systematic in the ways they assure the quality of their teaching, learning, research and other functions. The nature of teaching/learning encounters and their cumulative effect on student performance should be at the heart of any procedure for the assurance of quality. Institutions that have teacher (or faculty) development units, perhaps with associated proceedings for regular staff assessment, have an important means for improving the quality of their teaching and learning. Those whose distance-education programmes are supported by instructional design units have another advantage available to them. Given the segmentation of large organisations, the complementary nature of these specialised units is not always appreciated. Both, however, are concerned with the improvement of teaching and learning, and it is a mistake to assume that instructional design units should be confined to distance-learning modes. Particularly in dual-mode institutions, they have much to contribute to the improvement of face-to-face teaching. It is of course a common experience of teachers in dual-mode institutions that their work in the development and teaching of distance courses helps them improve the quality of their face-to-face teaching. There is a strong case to be made for considering teacher development and instructional design as two related aspects of a single unit.

98. Questions of a different order are inherent in the wider economic context in which all institutions of post-secondary education now find themselves in many OECD countries. One of the main reasons why distance education is attracting so much attention from governments is the hope that through economies of scale, unit costs over the long haul will be lower than for comparable face-to-face courses, and the large expansion of post-secondary education that all countries foresee will be achieved at less cost to taxpayers. An accompanying belief is that post-secondary institutions can be made more competitive in the future than they have been in the past. The personal circumstances of large numbers of that increasingly diverse student population brings both of these policy interests into a powerful conjunction. Students are looking for flexible ways of pursuing their studies, and the increasing user-friendliness of computer technology can provide answers to their needs. In such a competitive environment the policy expectation is that providers of distance education, whether in open or dual-mode institutions, will be better placed to increase their market share of an increasing demand for post-secondary education. And because the market will be competitive in terms of quality for price, all post-secondary institutions will have to give close, continuing attention both to the quality of their courses and supporting services and to the actual costs of producing and maintaining them.

99. This opens up a great many questions that cannot be taken up here. Four general comments can, however, be made. The first is that, thought of in market terms, post-secondary education is a great many markets, all with special features. It remains an open question as to how far many of these markets can be internationalised to reap the benefits of economies of scale. The prospects are likely to be brighter for courses in mathematics, science, engineering and information technology than for courses in education, law, health, social welfare, agriculture, horticulture and fisheries, and in a great deal of continuing professional education, where national, cultural and regional factors exert strong influences on what is to be taught and how it should be interpreted. No doubt there will be plenty of scope for the educational equivalent of fast-food outlets but it seems equally likely that there will be a continuing demand for boutique industries as

well. To take a current example, it will be interesting to see the results of efforts now being made by various universities to internationalise the teaching of courses in management by distance means.

100. The second comment is about educational values. Most teachers, at whatever level they teach, have the attitude of craft workers. They expect to have control of their entire operation and to put their personal stamp on it. They look upon the students they teach as "their" students, with whom they are in a personal relationship. These are the things that give them their job satisfaction and shape their self-image as teachers. There are features of distance education as organised in some open universities that teachers who were nurtured in this face-to-face tradition will want to resist. They can be expected to oppose arrangements under which some teachers develop courses they do not teach and others teach courses they have not been involved in developing. But industrial arrangements, and the partitioning of the traditional role of the teacher, are probably unavoidable in large-scale teaching operations driven by the efficiencies that go with economies of scale.

101. The third comment grows out of the second and has to do with the public roles of post-secondary teachers. As well as teaching their students, they live as members of local and national communities. Their knowledge and expertise and the fruits of their research and publications have impacts which are valued in various ways by people living in these communities. The result is that strong, mutually beneficial bonds develop between post-secondary institutions and their cities and regions. In the language of the marketplace, local institutions can be expected to build up a good deal of brand loyalty. In facing a future in which they are adapting themselves to different student populations in competition with rival and perhaps remote providers, local institutions have advantages they can exploit. Part-time and distance students can be expected to prefer institutions that are close to them so long as their courses are of good quality and their fees reasonably competitive. Local employers and community organisations can be expected to have a similar bias.

102. This suggests that countervailing influences are at work. In a competitive environment it also suggests that face-to-face institutions confronted with the alternatives of becoming dual-mode or operating on constrained budgets will decide to become dual-mode, at least to some extent. By taking that option, they will place themselves in a position to respond to future market uncertainties by learning how to play open learning institutions at their own game. On Rumble's analysis, they would bring advantages to that contest that open universities might not be able to counteract. They would preserve cherished academic values even while they adapted to the requirements of distance modes because their teachers would remain in control of the courses they developed and taught, regardless of mode. Becoming dual- (or mixed-) mode would require them to come to terms with the telecommunications revolution and, by so doing, they would then be able to respond flexibly to the demands and expectations of their local communities.

103. Fourthly, there are the apprehensions of post-secondary teachers. In their extreme form these are expressed in nightmare scenarios. Teachers in face-to-face institutions fear the prospect of more students without any compensating increases in operating budgets. Their institution may or may not be prepared to become dual-mode with the aim of providing courses of good quality to a larger enrolment. Government funding policies may not allow them to spend in advance the money they would need to outlay to diversify their teaching activities. Teachers then see themselves caught in a downward spiral: more students leading to larger classes and/or increased lecturing responsibilities. If they are to maintain standards, it will be at the expense of research, scholarship and publication. If the reputation of their university is put at risk, what chance will it have of holding and recruiting the best teachers? Many teachers fear that from a combination of influences over which they personally have little or no control their institutions will be left by the wayside.

104. Distance teachers, particularly in dual-mode institutions, also have a nightmare scenario. They fear that much of the enthusiasm for educational solutions yoked to sophisticated forms of information and communication technology will turn out to be one of false hopes. For the most part they use relatively low-tech equipment. What they need is firm and consistent institutional policies for conceptualising, developing and managing effective technologies of distance teaching and learning. If there is conservatism in their response, it rests on the proven experience of people and institutions that have already demonstrated what is needed for distance-learning of the highest quality to take place. They are sceptical of claims made on behalf of information and communication technology on grounds of effectiveness, simplicity, reliability and cost. If the enthusiasm for sophisticated information and communication technology is later shown to have been misplaced, they see themselves with the same operating problems but without the benefit of the money, time and energy which, in different circumstances, might have been directed to overcoming them.

Section 10: Speaking to the Questions

Who will be the delivery actors of post-secondary distance education?

105. Among the three questions introduced at the beginning of this report, the answer to the first of these will be strongly influenced, if not determined, by the predisposing decisions of governments. Governments set the conditions within which publicly funded educational agencies develop their institutional policies. Many OECD governments have recently reviewed, or are reviewing, their basic policy stances, with important implications for present or prospective delivery actors in post-secondary distance education. Different emphases are apparent but there are some common themes. More responsibility is being devolved to the institutions themselves to determine their own objectives and to take their own initiatives to achieve them within broad policy guidelines, making, as they see it, the best use of their funds. Funding arrangements are changing and, as well as being more stringent, are being related more to each institution's output of appropriately qualified graduates than to its input of staff, equipment and accommodation. Institutions are being urged to become entrepreneurial and to see it as their role to be responsive to changing demands for programmes of study including, as an important motivating incentive, new and still to be formulated programmes. Students, particularly for graduate and continuing education programmes, are being required to pay all or much of the cost of their courses and this, from the side of consumers, is intended (among other things) to exert a market discipline on the producers of such courses. Some governments are removing barriers to private sector initiatives on post-secondary education and training; some as a matter of policy are encouraging private providers to compete for contracts with public institutions. Long-standing distinctions between public and private sector spheres of activity are being removed. Protected monopolies which public institutions have traditionally taken for granted are being transformed into markets in which public sector institutions will be competing with private sector interests and also -- and perhaps more importantly, with each other.

106. To the pressures for change coming from governments are to be added those arising from changing enrolment patterns, the new forms of education and training to be provided, and the pervasive influence of new forms of technology. Few post-secondary institutions can remain immune to these pressures and influences, and by no means all of them can be assured of a continuing place in the sun. Some could find themselves merged with, or taken over by, other institutions and, as time goes on, their teaching missions might be broadened or changed altogether.

107. There has probably never been as much institutional ferment in post-secondary education and training as there is now. This does not so much concern changes of status as, for example, when a polytechnic becomes a university, as of changes in the way institutions are relating to each other under new operating conditions. More important for providers of distance education are the new kinds of relationships that are beginning to form between institutions and other organisations and agencies. These can best be thought of as strategic alliances. They are contractual arrangements that institutions enter into to protect or advance mutually agreed objectives. They are becoming as important for existing as for prospective providers of distance education. All forms of organisation have inherent problems, of course, and it is as well to note as an aside that consortia and strategic alliances are not always assured of success.

108. The following examples illustrate some of the different sorts of initiatives that are now being taken in various countries:

-- The National Technological University (NTU) in the United States is a consortium of 45 graduate engineering schools. From its headquarters at Colorado State University it contracts with particular faculties to offer courses by interactive video and arranges for them to be transmitted in real time to students who will be widely dispersed in North America. Students are enrolled in the school whose programme they are taking, meet its requirements and receive its qualification. The financial arrangements are advantageous to students, the universities in the consortium and to NTU.

-- The Open Learning Foundation (OLF) in the United Kingdom is a British response to new opportunities for open learning in advanced academic and technological fields. It is also a response to government policies to increase enrolments and to reduce unit costs. The OLF is positioning itself in an important niche in a national system that can be expected to increase the range and volume of distance courses. It does not enrol students: it draws on the intellectual resources of more than 20 universities to provide academic and professional services to university administrators and teachers who are delivering open- and distance-learning courses within their own programmes of study.

-- The Open Learning Agency of Australia (OLAA) was established in 1993 as a radically different way of delivering distance education within the wider context of open learning. The Agency is a consortium headed by Monash University in association with other leading dual-mode Australian universities and the Australian Broadcasting Company, with initial funding from the Commonwealth Government and other contributors. The OLAA will not award its own degrees but will facilitate access for people living anywhere in Australia to the courses and qualifications of the member institutions of the consortium.

-- The National Distance Education Centre, based at the Dublin City University and under the auspices of the Ministry of Education, is a consortium which draws on the resources and expertise of universities and other post-secondary institutions. It provides study programmes for people who are unable to attend face-to-face courses or who are seeking a second chance to study at post-secondary level. Its recently launched degree in humanities, for example, was designed and accredited by six universities. The students taking it follow a common programme supported by the Centre and receive their degree from the university in which they are enrolled.

-- New Zealand, another small country, has abandoned the use of centrally developed, national

solutions. Time-honoured policies based on government regulation have, since 1989, been replaced by policies that require institutions to manage their own affairs in an environment which they are to assume to be competitive. Institutions that had previously not taught at a distance are making exploratory forays (limited by funding stringencies) and are developing working relationships with telecommunications and broadcasting companies. Telecom New Zealand has constructed its Telelearning Network as a national (and international) electronic infrastructure to be used to link sites for the purposes of interactive learning.

109. Other initiatives stem from governments that have policies for stimulating entrepreneurial activity through tenders from public sector providers competing with each other and with private enterprises. In many countries this is becoming a standard way of managing and funding the provision of training within industry. Similar initiatives are being taken by large enterprises. They define the educational and training objectives they want to achieve for their workforces, tender for them and award contracts to the institutions or enterprises that best match their requirements of quality and price.

110. How far private sector enterprises will make inroads into the post-secondary education "industry" is an open question. The potential for "market penetration", particularly in populous countries and in those which that share common languages, appears to be considerable. The demand for non-university post-secondary education and training and for continuing professional education will be very great. In most OECD countries these fields are comparatively less well developed than university programmes for undergraduate study. They are the focus of intensifying professional and government interest. One way or another, more public money seems certain to be directed towards them and many countries are using funding mechanisms that encourage private sector enterprises to become involved. Again, telecommunications hold an important key to the future. They make it possible for students to become members of learning networks while remaining in their workplaces. They also make it possible for members of a dispersed teaching faculty to communicate with each other, to collaborate in the development of teaching materials and take part in teaching programmes without being physically present.

111. In countries where post-secondary education and training is being deregulated there is in principle no reason why projects that lead to the development and delivery of educational "products" should always be initiated by educational institutions. The field is opening for other agencies and companies to mobilise their own strategic alliances which would enable the buying in of their own educational expertise. Publishing and broadcasting companies have done this in the past. With the convergent interests that telecommunications, computer and publishing companies now have in educational markets for self-study courses, an increase in the number of private sector providers of distance education seems more than likely.

112. The scene is thus being set for a vast increase in institutional networking, with much more scope for entrepreneurial activity in post-secondary education and a blurring of earlier distinctions between public and private sector approaches. Among other things, this raises questions about the regulation of post-secondary education under conditions where there may well be many more delivery agents competing with each other under market conditions. Governments are under increasing pressure to constrain the costs of post-secondary education. But they also have obligations to their citizens to maintain sound academic, professional and vocational standards. Students who feel they are being "ripped off" can also use electronic networks to register their protests or engage in political action. The idea of a "bill of rights" for distance learners is being discussed in some countries. Is it to be *caveat emptor* or are the providers of post-secondary education to be required to meet and maintain specific standards of performance?

Is the dual-mode university (face-to-face and distance education) the likely future of all higher education institutions?

113. Only a bold person would answer this question unequivocally for all higher education institutions in all OECD countries. There are at present three broad types of institution: those that teach entirely or almost entirely face-to-face students on campus; those whose enrolments are made up entirely of distance students, though their study programmes may well include some face-to-face teaching; and those that combine face-to-face and distance teaching modes. Different answers are possible for each type of institution.

114. For the third type, those that are already dual-mode, there is no reason to doubt that they will continue to combine distance- with face-to-face teaching. All the influences discussed in this report confirm the suitability of this kind of institutional response to changing demands and expectations. This is not to say, however, that, simply by existing, dual-mode institutions will be as effective in their work in distance-learning as in face-to-face teaching. Most dual-mode institutions have inherent problems as providers of distance education. Being dual-mode and being *effective* as a dual-mode institution are two different questions. These, and the institutional policies to overcome them, are discussed in the next section.

115. Institutions of the second type--single-mode distance universities--may well find themselves under much less pressure than single-mode face-to-face universities to become dual-mode. The Rumble option is one opening to the future but there are others. They are, let it not be forgotten, institutions that are designed, managed, staffed and funded to advance the cause of distance-learning, and the future demand for this form of higher education will be great and never-ending. Simply by continuing to develop themselves as institutions that provide quality products and broadening as opportunities arise the range of their teaching programmes, institutions may find a winning formula without having to become dual-mode.

116. Furthermore, the pressure to make more use of information and communication technology may well be stronger than any pressure to become dual-mode. Within distance-teaching institutions it is likely to have a greater influence on future plans and funding priorities than proposals to branch out into face-to-face teaching. This approach would be justified on the grounds that institutions should stick to what they do best (which, in the language of the marketplace, means concentrating on their core business activities). It might well lead to strategic alliances and the formation of consortia, but for different institutional purposes.

117. The British Columbia Open Learning Agency (BCOLA) provides one illustration. In terms of its teaching programmes it is a single-mode distance-education agency. Its teaching programmes are broadly comprehensive, ranging from second-chance, community and vocational courses to degree programmes. It runs the Knowledge Network, British Columbia's educational television station. The governing board of the OLA includes members of the other universities of British Columbia (which have their own distance programmes) with the aim of mixing and matching the contributions of various institutions, some in the form of distance courses, others face-to-face, to provide learning pathways towards a widening range of post-secondary qualifications. The BCOU is responsible for negotiating the recognition of credits for transfer purposes from community colleges and between universities for degree purposes. It is also building alliances with industry through its workplace "Training Scheme ' which attempts to match OLA expertise and skills with training requirements in workplaces.

118. The BCOLA is thus part of a post-secondary educational system but confines its teaching to distance modes. In the larger provincial context in which it is working there is no need for it to become

dual-mode. Through its governance it is in communication with other post-secondary agencies with the aim of achieving agreed institutional policies and more flexibility and choice for students[15]. It is also a co-operative, not market-driven operation. The working assumption is that efficiency, flexibility and choice -- touchstones of libertarian market philosophy -- will be achieved through institutional co-operation.

119. Universities of the first type, those that teach largely or solely face-to-face, will need to give the closest attention to a broadening of their mission to include distance education as a carefully conceived, properly managed and funded mode of teaching and learning. For publicly funded universities (and other post-secondary institutions) the policies of their governments will be a determining factor. As with all institutions of higher education, they are being courted with the promises of information and communication technology. That, however, is by no means synonymous with distance education. A university's interest in information and communication technology can be confined to research and experimental work on a relatively small scale in one or two departments. A commitment to distance education as an alternative teaching mode requires a new technology for teaching and learning to be conceived, planned and brought into routine operation. Information and communication technology may well have only a small contribution to make to such a development.

120. The focus of attention during the last generation has been on undergraduate programmes, but universities that decide to become dual-mode in the future will be responding at least as much to possibilities associated with graduate and continuing professional education. For this reason alone, more face-to-face universities can be expected to become to some extent dual-mode. The policies of prestigious universities -- whether publicly or privately funded -- will exert an important influence. Most stood aloof from distance education when it was associated with disadvantage and what were surmised to be relaxed admission standards. They serve national and international rather than civil or regional communities. Competition for enrolment is likely to be such that they may not feel under any pressure to diversify their offerings for undergraduates. But, as "market leaders", they may not want to pass up opportunities to develop their graduate programmes, and that will require them not only to use information and communication technologies but to employ sound distance-education technologies as well. And to the extent that developments along such lines would enable them to add to what they may already be able to offer face-to-face students by way of independent, self-directed study, they would have another good reason for embarking on them. It seems reasonable to expect that dual-mode approaches will become more attractive to face-to-face universities in the future than they have ever been in the past.

What should then be the interaction between both modes of education, and the consequences on teaching staff, content and design of course materials?

121. The future that could be envisaged is one in which, in their day-to-day responsibilities, some students will be studying on, some off, campus and some will use both modes. Teachers will also differ in the nature of their teaching responsibilities: some will teach campus students only, some may well teach off-campus students only and some will teach both. All teachers will make some use of teaching methods that are resource-based and require students to take responsibility for their own learning, whether working alone or co-operatively. Increasingly, therefore, however they are classified, students will be interacting with learning resources of one kind or another as well as with their teachers or tutors. In that future, the question would cease to be how two modes of education interact but how educational institutions are organised to support teachers for whom a range of back-up resources are essential to their technologies of teaching and learning. That question leads straight into discussion of their inner decision-making processes and the salient features of their institutional culture that shape those decisions.

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122. Educational institutions, like all human organisations, develop distinctive cultures. They develop self-images in relation to which those who control their destiny respond to changing circumstances, encouraging some developments, accepting others, and ignoring or resisting changes they regard as unwelcome or not appropriate for them. Universities are prime examples of institutional distinctiveness in the values they affirm and the inner processes by which they make decisions, advance or protect their interests, and relate to the outside world. But other post-secondary institutions also have distinctive cultures, even though they may be of more recent origin. Some develop aspirations to become universities and this leads them to concentrate on "higher-level" work, sometimes at the expense of their "lower-level" responsibilities. Others, such as community colleges, see it as their mission to develop close working relationships with local industry and their local communities. Whenever educational institutions are confronted with possibilities of change, and are themselves able to influence the outcome, their internal debates will be shaped by their members' perceptions of the kind of institution they belong to.

123. The distinctive thing about open universities (and also about open polytechnics, open colleges and open-learning agencies) is that they have been created solely to develop programmes of study which they will teach only to distance students. Their planning, management, funding and organisation are all directed to that objective. They bring teachers, media specialists, broadcasters, printers and publishers together in co-operative arrangements that have the character of production processes. They are large and complex, are driven by timetables and they must operate with clockwork efficiency. The distinguishing feature of open universities is to be found in their combination of academic and managerial principles. On the academic side they have pioneered forms of co-operation by directing teams of university teachers to conceive, plan and write courses of study by using interdisciplinary approaches, placing subjects in new intellectual contexts and exploring them from new perspectives. They have given new meaning to peer review through their consultative, moderation and approval processes, and through the public nature of their study materials and supporting publications. On the managerial side they plan and fund their work in cycles which begin with the advance planning and development of course materials which later come on stream as courses of study for which students enrol and are tutored and supported in various ways and are then revised for further use. The ability to plan ahead and spend money on the development of courses that will not enrol students and therefore earn money for the institution before one, two or three years' time is a most important characteristic of open universities and other open-learning institutions.

124. These academic and managerial characteristics are essential to the efficient conduct of organised programmes of distance-learning. They are much less in evidence as settled features of the internal organisation of dual-mode universities. A few universities -- the University of New England; Deakin and Murdoch in Australia, for example -- were from their beginnings planned as dual-mode institutions[16]. Typically however, face-to-face universities have taken on distance-learning functions almost without noticing. Initiatives that were taken out of the limelight and on a small scale have, during the last decade, attracted much more public attention than their proponents might have expected. Administrative arrangements that began as small, informal undertakings by teachers who were personally committed to providing opportunities for off-campus students may well have persisted long after the pioneering days have passed. Where that is the case it is usually because those who speak for distance education have been less than successful in breaking down institutional resistances to what they are doing. In terms of their inner management, dual-mode institutions are problematic in ways that open universities and face-to-face universities are not.

125. It is not simply that the distance mode is of quite recent origin in most dual-mode universities. Markedly different views are held within dual-mode universities as to the educational legitimacy of distance-education approaches for university-level courses. Institutions that have developed for generations

(in some cases for centuries) in an ethos that values the unique, personal influence of university teachers on full-time students and the educational benefits of campus life, have to come to terms with the very different approaches to teaching and learning signified by distance-education approaches. The underlying issue during the educational debates of the last quarter of a century was whether distance education, however defined, could do as good a job as face-to-face teaching. The assumption was that face-to-face teaching was the norm in relation to which distance education had to prove itself. The educational and social values subsumed in that norm were such that distance education could scarcely ever be expected to achieve it. And it was usually taken for granted that, simply by prescribing the norm, proponents of face-to-face teaching were themselves achieving it. Those responsible for distance education programmes frequently felt that they were alien to its predominant cultural values. In the unending competition for staff, equipment and running expenses they have usually been among the poor relations.

126. One consequence of this internal debate has been to generate a discourse of advocacy that has emphasized differences between distance- and face-to-face modes. And the advocacy has been necessary because, typically, the processes of internal decision-making and management in dual-mode universities do not give proper weight to the requirements of its distance mode. But the central argument of this report is that times are changing. Earlier, sharper distinctions between face-to-face and distance modes are becoming blurred. New technologies are opening up important possibilities that university teachers should embrace, regardless of the circumstances of their students or the previous manner of their teaching. The uncertainties of competitive environments are such that all who draw their pay from an institution have a personal stake in its successful adaptation to whatever the future holds.

127. In the world that is emerging in the OECD countries, it is becoming less open to proponents of face-to-face university education to determine the norms and conditions under which teaching and learning will be carried out. Students and potential students have a greater range of choice as to where and how they will pursue their studies in post-secondary education. Developments in communication technologies are making it possible to create learning networks that combine varying amounts of face-to-face teaching, self-directed study and tutorial assistance. The student populations who are experiencing this growing diversity in the way that teaching and learning is becoming available are themselves the first generation of the telecommunication age. They have grown up with computers and multi-media learning packages in ways that, so far, many of their teachers in post-secondary institutions have not. The challenge to a face-to-face university is to transform its internal culture. The decision to become more open and flexible and to found its teaching on a sound pedagogy of learning has revolutionary possibilities.

128. In terms of openings to the future, the issue then becomes how to shape a discourse that teachers in both modes will feel they are part of and to whose further development they can all feel they have significant contributions to make. That should be done by concentrating on elements from each mode that have pedagogical value in an era in which effective teaching and learning could be greatly enhanced by information and communication technologies. To put the matter that way is to change the terms of the debate. The question is no longer whether face-to-face universities should become dual-mode but how they can become more open and flexible in their teaching and base it on principles of good practice. If they are to answer that question, universities must correct the biases of their internal culture, and, to do that, they must review and (probably) refashion the structures and processes that influence their effectiveness as learning institutions. Specifically, this calls for:

- an institutional commitment to excellence of teaching for all its students through whatever pedagogic strategies it decides as matters of policy to use to meet their circumstances and

learning requirements, having regard to the attested contribution of information and communication technologies;

- effective internal decision-making procedures for the setting of academic standards, goals and priorities, the planning and funding of the teaching/learning implications of academic reviews and developments, and for the personal accountability of teachers towards their students;

- a continuing focus in the institution's day-to-day life on the requirements of effective teaching and learning through the work of teacher (or faculty) development units and other arrangements such as programmes of research and development that actively involve the teachers;

- the effective planning, management and evaluation of arrangements for resource-based teaching and guided independent study, whether for on-campus or off-campus students, having particular regard to the known requirements of such systems for up-front capital expenditure and efficient servicing networks;

- arrangements for the induction of staff into the nature of their teaching responsibilities and programmes of staff development aimed at assisting all teachers to improve their performance as facilitators of student learning; policies for moderating teaching loads according to the differing demands of their teaching responsibilities, including responsibilities to develop and revise study packages for resource-based learning and guided independent study; and policies for recognising and rewarding excellent teaching;

- open, flexible policies for the enrolment of students, the recognition of prior learning and the pace at which students may pursue and complete courses and study programmes; accommodating regulations for students who want to transfer from on-campus to off-campus or combine a mixture of both; and effective arrangements with other institutions for them to transfer enrolment and credit.

129. It is a prime responsibility of institutional leadership to ensure that all these factors are properly attended to in the interests of effective teaching/learning, however organised.

130. Important as these factors are, however, they are not by themselves enough to change the internal culture of universities and other post-secondary institutions. Most of them depend on public funding, and the nature of that funding almost always precludes investment in programmes of study that have long planning horizons and make intensive use of academic and related professional inputs in their planning and development stages. Indeed, the experience in many countries is that allocations of finance beyond the current operating year are becoming more and more difficult to make. But it is not possible to develop programmes of distance-learning or convert face-to-face courses to distance modes or to resource-based learning approaches without the ability both to plan ahead and to commit expenditure in advance. Many public institutions are locked into traditional ways of teaching by the rigidities of funding schemes imposed by governments. New approaches to institutional funding will be required in a future in which all institutions must be more attentive to the differing expectations of students and to new ways of satisfying them.

Section 11: Pushes and Pulls

131. Wherever there are pressures for educational institutions to change the nature of their work it is important to have a clear view of those pressures and of the capacity of the institutions to respond constructively to them. At the present time, it would seem that open institutions on the one hand, and face-to-face and dual-mode institutions on the other, are very differently placed. The outside influences that are pushing open institutions to be open and flexible in their responses to new possibilities are matched by internal cultures that are pulling them in the same direction. With, no doubt, notable exceptions, the same synergy is not a strong feature of face-to-face and dual-mode institutions. It is not simply that their advocates of self-directed learning are perceived to be minority interests in larger academic communities. For the most part, a proper basis for constructive dialogue is lacking between an institution's various teachers, whose knowledge is the reason for its being, and the respective emissaries of distance; resource-based, or self-directed learning and of information and communication technologies.

132. There are, in fact, two dialogues that have to go on at the same time. There is the dialogue between those who are expert in their subject and those who are expert in translating it from oral teaching modes to courses of study in which a teacher's knowledge and teaching skill is encapsulated in learning materials. In that respect, of course, dual-mode institutions are better placed than face-to-face institutions, few if any of whose teachers may have the latter expertise. Then there is the dialogue between teachers and the emissaries of information and communication technologies. Where that dialogue is joined, most teachers find themselves on the defensive and often at a loss. More is involved than mutual incomprehension. Teaching, as noted earlier, remains essentially a craft occupation. It is also a cottage industry. The business of teaching and learning has not so far benefited from more than a tiny fraction of the funding for research and development that stands behind the current state of the art in information and communication technology. When, therefore, teachers are asked how they could use new forms of technology they frequently have little more than personal experience, supplemented by that of their colleagues, to guide them. Instead of being able to prescribe requirements based on research and development in the teaching of their subject--requirements that would specify the development of suitable forms of software--they are typically confronted with new items of equipment that have been designed primarily for other purposes. Instead of being pulled towards technology that will provide answers to their pedagogical questions, they are being pushed towards items of equipment that are being promoted as the latest "hot" product in some company's marketing strategy.

133. One of the unsatisfactory features of the situation that has developed over many years is the modish nature of experimentation in the educational uses of communications media. Beginning with radio in the 1930s and television in the 1950s, various technological innovations have been heralded as educational panaceas. Audio graphics, videoconferencing, computer graphics and multimedia linked by servers to hypermedia are the contemporary offerings. Not until use of each new technology has passed beyond the experimental stage have its educational limitations become evident. This is a consequence of starting from the wrong end, looking for educational applications for new technology instead of first being clear of the educational objectives for which suitably prescribed equipment and supporting infrastructures could then be developed and tried out. It is reasonable to suppose that the weaknesses as well as the

strengths of particular technologies and mixes of technology would be shown up during such processes of research and development. It is not surprising either that some of the best courseware so far developed for educational purposes is the work of computer companies. They have the commercial impetus to commit themselves to research and development in courseware as well as hardware products with which they expect to increase their market share.

134. Nor do all educational users have the same policy interests. Audio- and videoconferencing have much to offer institutions that are looking for ways of coping with course enrolments which are too large for lecture rooms, that are organising teaching programmes where face-to-face students are on more than one site and are reaching out to off-campus students. So long, however, as such arrangements are confined to real-time presentations, they are limited in the amount of interaction they can allow and they are accessible only while they are happening[17]. They do something, but not a great deal, to achieve the policy objectives of education systems where the demand is for vast increases in the amount, type and variety of education and training programmes of attested quality that students and trainees can study at times and places of their choice, in relation to which they can be active learners and over which they can have some control of their own learning. The guess is that the future for education systems lies with technologies that store sophisticated teaching/learning programmes and enable students to interact directly with them but in their own time.

135. But guesses are not good enough in policy-making. They should be turned into hypotheses to be explored and tested against the educational criteria they are intended to satisfy. Excellent teaching and effective learning, however they are achieved, are both the beginning and the end of the enterprise. The overriding aim of educational policy is to maximise this. Computers and telecommunications are already contributing significantly to that end and they have the potential to do a great deal more. The question is how to match technological means to educational ends, to produce results that are beneficial to learners as well as to investors in telecommunications and computer stocks. It is the message that matters, not the medium.

Notes and References

1. The following persons have also provided helpful comments on this draft: John Chick, Helen Connell, Anastasiou Christodoulou, Marion Croft, Patrick Guiton, Cedric Hall, Gary Hawke, Les Holborow, Dennis Irvine, Richard Johnson, Ian Mugridge, Maris O'Rourke, Lalita Rajasingham, Jack Shallcrass, Richard Simpson, Malcolm Skilbeck, Don Swift, and Ormond Tate.

2. See for example the report of the DEET/OECD Conference, "Elite to Mass Education", held in Sydney, Australia, in June 1993.

3. For Americans and Canadians, the word "instruction" may well have other resonances that blur the distinction made. Teaching positions below the level of assistant professor are often known as instructor: instruction is what they give, and their instruction can be as wide and deep as knowledge itself. In that semantic field, distinctions between knowledge and instruction are not as sharp as the one drawn here. By extension, instructional design, an essential element in distance education technologies, has wide connotations.

4. See, for example, W. Perry, "A Personal Account by the First Vice Chancellor", Open University, Milton Keynes, 1976.

5. Desmond Keegan, *Foundations of Distance Education*, second edition, 1990, p. 205.

6. "Open Distance-learning in the European Community", Memorandum COM(91)388 final, Commission of the European Communities, Brussels, 12 November 1991.

7. Stuart L. Smith, M.D., "Commission of Inquiry on Canadian University Education", Association of Universities and Colleges of Canada, 1991, pp. 84-87.

8. Other straws are in the wind. In Australia, for example, the National Distance Education Conference has recently changed its mandate, membership and name so that it can give greater attention to the application of distance- and open-learning technologies to all Australian post-secondary students, including those on campus. The new name is the National Conference on Open and Distance Education (*Campus Courier*, 8-14 July 1993, p.2).

9. *Op. cit.*, pp. 47-48.

10. The notion of duality can be ambiguous. Here it implies some degree of common experience among members of teaching departments with responsibilities for face-to-face and distance students in the same or allied courses of study.

11. "Review of the Open University" conducted by the Department of Education and Science and the Open University at Milton Keynes, 1991, pp. 51-54.

12. Greville Rumble, "The Competitive Vulnerability of Distance Teaching Universities", *Open Learning*, June 1992, pp. .31-45. See also Ian Mugridge's, comments in *Open Learning*, November 1992, pp. 61-62.

13. Personal communication from Dr. Cedric Hall, Director, Teaching and Development Centre, Victoria University of Wellington, New Zealand.

14. Except for the first, the principles discussed here were developed by Arthur W. Chickering and Zelda F. Gamson, published by the Johnson Foundation as *Principles for Good Practice in Undergraduate Education* and widely used in the United States, Canada and the United Kingdom. With assistance from Arthur Chickering and Janet Jenkins, they have been adapted to include possibilities now becoming available through information and communication technology. The principles are set out in three short booklets, each in the form of an inventory with questions and a rating scale for personal responses. Each booklet is aimed at a different readership: the institution as a whole, the teaching faculty and the students. The principles are the same but the detailed questions differ for each type of respondent.

15. Alan Davis, "Perspectives on Distance Education. Distance Education in Single- and Dual-mode Universities", in Ian Mugridge (ed.), *The Commonwealth of Learning*; The Open University of British Columbia, Vancouver, Canada, 1992, pp. 63-78.

16. John Chick, 1992, pp. .33-48, "The New England Model in Theory and Practice", Ian Mugridge, (ed.), *The Commonwealth of Learning*, Vancouver; F. Jevons, (Deakin University), "Distance Education in Mixed Institutions: Working Towards Parity", *Distance Education*, Vol. 5, No. 1, p. 26; Patrick Guiton, Murdoch University, "Murdoch University: Interlocking the Learning Modes", in Ian Mugridge, (ed.), *op. cit.*, pp. 93-104.

17. Audio and video tapes can, of course, be made and distributed both as a record and for "secondary" users.

III. THE FUTURE OF TECHNOLOGY IN POST-SECONDARY EDUCATION

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Introduction

Definition of post-secondary education

1. For the purpose of this report, post-secondary education will be defined as any type or form of education taken after graduation (which is generally at the age of 18). It includes professional and vocational education as well as continuing adult education or university education up to doctorate level.

The evolving socio-economic context

2. Many of the traditional assumptions, policies and practices of education are being challenged by issues which individually and collectively are stimulants for a new way of thinking about post secondary education. Each is a major challenge, requiring a response that is equally profound. They include:

Increasing demand for lifelong learning

3. During the last twenty years the number of people in post-secondary education has constantly increased and there is no sign of slowing down, mainly because a significant part of the labour force has to be more or less permanently retrained to adapt to a fast-changing technology. The reasons for that retraining are many. In some cases, the workers have simply been replaced by technology and must be retrained for other jobs; or the jobs have moved off-shore because of lower wage rates in other countries, or foreign competition has destroyed the national industry. Globalisation, competition and technology, as well as some new trends in the workplace, require education and training. Even if the individual's job is not adversely affected by the these trends, the way work has been done in the past is changing, and the skills that managers and companies need are also changing.

4. On the other hand, the long-lasting economic depression with its accompanying high level of unemployment is pushing an increasing number of adolescents towards a higher-level degree with the hope that it will make it easier for them to find a job.

Individual expectations and demands

5. Institutions are increasingly expected to offer instructional and support services based on the convenience of consumers rather than that of the institution. Education cannot escape from the demand for client-oriented services. The expectation is that a truly learner-centred education will be delivered directly to the individual at a time and in a place determined by the learner. Such personalised instruction depends on sophisticated delivery systems and portable learning tools which are made possible by the progress in digital electronics, even if they are currently expensive.

6. The economic climate has, however, caused almost all governments to tighten their budgets, including that for education. A first reaction of receiving less, we'll do less was declared unacceptable by governments for obvious political reasons. Other proposals to increase class size or the teaching duties of teaching staff were considered unacceptable by teachers, students and employers as being detrimental to the quality of education. There is, however, continuous political/social pressure to explore all reasonable alternatives for delivery of higher education services which cannot be ignored.

Pressures on facilities of institutions

7. The pressure on institutions inevitably leads to pressure on the physical limits of campuses and the maintenance and replacement of existing equipment. Estimates in various countries reveal that additional campuses or major extensions to existing ones will be required each year for the foreseeable future in order to meet the unmet demand for student places (for example, the California State University system estimates it needs to build the equivalent of a 10 000-student campus each year for the next 15 years).

8. It would be socially and politically unacceptable not to meet the existing demand for higher education, so ways must be found to reconcile available resources with the enrolment pressure and economic demand arising from lifelong learning. Recent developments in information technology open new avenues for exploration.

9. The use of technology in education (television, audio- and videocassettes, computers, etc.) was introduced some decades ago and has led to various experiments. However, the cost of equipment made the generalisation of these experiments mostly unrealistic. The decreasing cost and increasing ease of use of the equipment over the last decade have, however, led a number of experts to propose the use of technology as a financially viable solution making education more effective and more efficient. Other experts believe that the use of technology can improve education, but add that it is certainly no quick fix to the problem (between ten and twenty years will be necessary to make it a daily reality) and that there are many reasons for thinking that it may make education more expensive than it is today.

10. Finally, there is now a tendency to apply an approach to education taken from management -- re-engineering -- and to reconsider the idea that technology alone, whatever the amount of equipment used, does not solve any problem, or increase quality, or decrease cost. What is needed is a rethinking of the whole system without preconceived ideas and a redefinition of the way it is organised and how it works so that the technology can best be used to increase efficiency, effectiveness and, above all, quality while at the same time decreasing overall costs.

A Short Overview of Information Technology

11. For the purpose of this report, the information technologies are understood to include older, perhaps more traditional technologies such as print, audio and video, as well as the newer technologies of computers and telecommunications, whose main trend is their increasing level of integration in many applications (computers make telephone calls and send faxes; laser printers have at least one powerful microprocessor and megabytes of memory; cellular telephones include a radio transceiver, a microprocessor and megabytes of memory, etc.).

Developments in technology

12. Within the next ten years, the following technological developments will most probably lead to the development of new applications in an increasing number of homes in developed countries:

- integration of computers, television and telecommunications through digitisation/compression techniques leading to single devices including all three functions;
- miniaturisation and therefore increased portability with the help of radio communication;
- increased processing power in a constant volume, making available to the public simple interfaces for complex problems like voice input-output computers with their host of new applications.

Print, electronic publishing and electronic libraries

13. Even though the use of print in education appears assured for some years, there are signs that the printed word may be partially replaced by the electronic word in the long term as more and more journals and books (even those for the very young) are published in electronic form. A significant emerging trend is for books, especially textbooks, to be published in conjunction with accompanying disks and CD-ROMs containing items such as videos, pictures, interactive tutorials, exercises, test banks, and quizzes, which are either difficult or impossible to design in printed form.

14. Libraries are increasingly using computers for a variety of services from bar-codes for registering outgoing and incoming books to sophisticated navigation tools for retrieving information from books and journals through distant terminals.

15. At the University of Southern California, for instance, arrangements have been negotiated with a number of publishers, particularly McGraw-Hill and Elsevier, for the electronic publication on an exploratory basis of the full text of a number of journals and books. These are held in robot-controlled

silos which contain 6 000 tapes of 5 gigabytes each for on-line access, and a further 3 000 tapes are available for loading on request. An on-line laser printing service has been established to provide for the on-demand publication at USC of selected extracts from the full-text databases.

Radio and television

16. Broadcast television is a system designed to cover a given area for open-access reception without restriction. To transmit pictures from a camera to a receiver screen, it uses amplifiers, a transmitting antenna, electromagnetic waves in the open air, a receiving antenna and receiver circuits. Transmission uses UHF and VHF frequencies which propagate along a straight line only and therefore signals cannot always reach all geographical areas (either those hidden from the emitting antenna by natural obstacles like hills, mountains, etc. or those which are so far away that they are out of the range of emitting antenna). There are three main television standards (NTSC, PAL, SECAM). They are incompatible and, moreover, they all have rather limited audio quality.

17. Satellite television is a system where signals coming from the earthbound emitting antenna are received in the sky by a satellite, amplified aboard and then sent back to earth to any number of receiving antennae in direct sight from the satellite which, therefore, has to be stationary relative to earth implying an altitude of about 36 000 Km. The reception of the satellite signals imposes the use of a rather large dish , an amplifier and a decoder to convert the received signal to a form suitable for display on a television receiver. In many cases, the reception antenna belongs to a cable operator who redistributes the received signals to individual receivers through a cable, a so-called cable TV. At present, there is no agreement on a single international standard for satellite transmission.

High-definition television (HDTV)

18. High-definition television is a system with improved performance. It gives much sharper pictures, uses a wider screen (16x9 format) and has much improved audio (multiple audio channels allowing hi-fi sound and multi-lingual sound tracks for a film). However, these improvements require increased bandwidth compared to normal television, but bandwidth requirements can be reduced through the use of signal compression techniques which are developing rapidly. Because of its high cost, the use of complex consumer decoders and the absence, for the moment, of an international standard, HDTV will probably develop only slowly over the next few years.

Pay TV

19. Pay TV is an encoded broadcast television signal which can be distributed either by air, satellite or cable. At the other end the receiver shows a blurred picture and no sound unless the user registers and gets a decoder which allows reception of the original picture and sound. Of course, there is an initial fee for the decoder and a monthly subscription for its use. A variation of this is the so-called pay-per-view system in which the user pays only for the time used to watch the requested film.

Videoconferencing

20. Videoconferencing combines audio and visual media to provide interactive communication between two or more sites. Beside the one-way-and-a-half system television plus telephone, there is a less expensive two-way picture and sound system also called freeze-frame videoconferencing based on the use of still video phone or fax phone. Its only drawback is slowness: a picture transmission will take a minute

or two through a telephone line because of the narrow bandwidth of the line and the definition of the picture.

21. Full-motion video will remain very expensive because of the wideband channels needed to send video, audio and data simultaneously even with the use of fast compression/decompression techniques which reduce the required bandwidth.

22. In most cases the technique used is a mix of the various methods to optimise the total cost. For example, Alaskan public broadcasting and government officials are planning a distance-learning network to cover the whole state. A blueprint of the system was submitted to Alaska's Governor at the end of September 1993. The new distance-learning network will be a hybrid system using optic fibre for major population centres and microwave and direct-satellite transmission for remote areas. The fibre and microwave links will offer two-way video; the sites served by satellite will receive incoming video but will communicate back by telephone.

Increased power of computers and communications

23. Both computing and communication technology continue to develop at a rapid pace and will impact education to the same extent that they impact other areas of human activity. Although accurate and detailed forecasts of developments in both technologies are difficult, the following trends can be observed.

24. Because of international competition, every few months computer manufacturers produce a seemingly never-ending succession of new models, each more powerful and with more features than the previous ones. Computing equipment has become faster, smaller, more reliable and cheaper with the capability of storing and processing increasing quantities of information at greater speed.

25. Features of recent desktop computers already include audio and voice input-output; video can now be displayed on the same screen as animation and text. Prices of computers continue to drop, making the possibility of an interactive multimedia computer on students' desks a reality and not just a dream of educational innovators.

26. Among examples of significant developments are the inexpensive, hand-held computing devices which can be used for many purposes. The name intimate computer has already been coined by Allan Kay, who is widely considered as the father of the modern personal computer. He was one of the leading researchers at the Xerox Palo-Alto Research Center (PARC), a well-known think-tank for computer scientists in the 1970s from which many modern developments have sprung. Kay refers to three types of paradigms: institutional computing (mainframe) in the 70s; personal computing of the 80s (which, despite all claims, still affects only about 10 per cent of the population and remains largely institutional) and the next leap forward, intimate computing, which he predicts will affect the other 90 per cent of the population in the late 1990s and the early 2000s.

27. The merging of personal and intimate computers with consumer electronics (television, radio, telephone, camcorders, VCR, CD drives, high-fidelity devices and other electric appliances) will certainly have wide-ranging impact on computing in general and on its use in education. If the new intimate computers are readily available to the extent predicted, what impact will this have on the availability of computing and communication facilities for students of all ages and in all places?

The development of electronic networks

28. The 1990s are seeing an exponential growth in the use of electronic networks connecting computers and other networks in a web of communications which link many sectors of education, government, industry and commerce. The general vision of the future is one of individuals accessing a variety of computing and information resources mounted on computers that vary from microcomputers to supercomputers located anywhere in the world. In this vision every teacher, the administrative staff and each student will have a personal computer. It will be attached to a local network which, in turn, will be connected to a national network which has international links around the world. Ideally, the individual will have access to information on the local, national and international network as if it were a personal computer.

29. A network consists of a number of computers linked together which enable all the users of the computers to communicate and share common resources such as software, databases, printers and scanners. An additional computer (called a server) is normally added to the network to handle user sharing.

30. Various types of computer networks exist:

-- Local-area networks (LAN) using cable wiring between computers not more distant than a few hundred metres (generally inside a room or a building). Using normal telephone cable and standard interfaces, the data flow cannot exceed 1 megabit per second; with special cables and a special interface (Ethernet) the data flow can reach 10 megabits per second.

-- Wide-area networks (WAN) spanning a few square kilometres generally built by interconnecting some LANs through appropriate computers called bridges or gateways (which are transparent to the user); the data-flow speed has the same limitations as above.

-- National networks generally using the switched telephone lines for data transmission which restricts the data-flow speed to less than 10 kilobits per second. Various data-compression techniques can bring the speed up to 50 kilobits per second, but this is far from sufficient for the transmission of large quantities of information--such as graphics or pictures--or live colour video which, for smooth viewing, requires over 100 megabits per second. For that purpose many countries are installing or plan to install very broadband data transmission lines (mainly optic fibres) known as Integrated Services Digital Networks (ISDN). This does not completely solve the data-flow problem because with ISDN the outgoing bits are not sent all together but in packets from a few kilobits to a few hundred kilobits wide; at the receiving end these packets have to be stored until the whole page or picture or video frame has arrived, and they must then be assembled in the right order before being sent to the screen. This implies that a large enough storage medium (disk) is available at the user's end and that it will be able to send the stored data to the screen at the requested 100 megabits per second speed; whereas 10 000 megabit disks are available today (at high cost), the speed of data from disk to the screen does not, on present-day personal computers, exceed 10 megabits per second at best. There are techniques which do allow the requested speed but they have yet to be implemented on microcomputers; this will, however, not happen, for commercial reasons, until an agreement has been reached on an international standard.

National networks

31. A number of countries, which set up networks originally to serve the academic community, are considering expanding these networks into national networks which will also serve the K-12 schools, technical and further education and adult and continuing education, as well as the universities.

International networks

32. International networks, in turn, are built by interconnecting various national networks through gateways", which are computers with highly specialised software designed to allow different computers to communicate. This has been made possible through international agreements on interconnection standards called protocols . (Protocols are the basis for computer networks in the same way that railway tracks and signals are the basis for rail networks.) Networks now span the world through telephone lines, satellites or radio waves, and allow connected users to communicate with all other users or with a connected server anywhere in the world.

33. The most impressive international network, but by no means the only one, is Internet. This is a network of 1.2 million host computer systems and some 20 million individuals world-wide. Internet has shown consistent growth in recent years, doubling the network population every five months. Current predictions are that such growth will continue for at least the next few years.

34. Any difficulty experienced in accessing information on a network results from the sheer volume of information which is available. Users have to decide where start looking for the required information. This difficulty can be partly overcome, however, with the help of specialised software. For instance, a development known as WAIS (Wide Area Information Server) helps the user to search a number of sites as part of a single inquiry, with the advantage that WAIS allows queries to be written in almost free-form English as opposed to many information-retrieval languages which impose a very strict syntax.

35. Another significant software development is GOPHER, which provides network users with a consistent method of accessing different types of information resources around the world, regardless of the type of computer used. Resources include electronic books, journals, directories, library information, databases, campus information, specific subject information and galleries of pictures. There are now over 2 000 GOPHER servers around the world storing more than 1.5 million documents.

36. An index of titles for GOPHER items is accessible through software called VERONICA (Very Easy Rodent-Oriented Net-wide Index to Computerised Archives), which searches the menus of all GOPHER servers and also provides keyword searches of the titles. For example, giving VERONICA the two keywords, national and networks , brings in less than a minute about 100 titles of articles stored in different computers around the world. The full text of any article can be read and stored locally by simply clicking on a menu item (provided the full text has been stored in the remote server).

37. However, information retrieval on an international network or even inside a given database requires a minimum of training in database structures, some knowledge of what a query language looks like and, above all, a good knowledge of the domain of investigation, not only to keep the retrieval time (i.e. cost) to a minimum but also to be able to keep the so-called noise (non-relevant items) and silence (relevant items which are in the database but do not appear on screen) to a minimum. A non-specialist in a domain with no experience in data-base retrieval can spend hours (and much money) investigating databases in that domain without achieving significant or meaningful results.

38. Other very recent developments which provide similar but more sophisticated facilities are MOSAIC and the World Wide Web.

Network applications

39. Internet, and the networks forming part of it, are organised around the fundamental idea that information should be exchanged without restriction in a free and open environment. A number of types of communication are possible by means of networks. They include (not exclusively):

- electronic mail (e-mail);
- bulletin board systems (BBS);
- computer conferencing;
- electronic data-base retrieval;
- with the advent of sound and video capacities, computer-mediated audio and video conferencing are now possible;
- a mix of any number of the previous systems on a single terminal.

Electronic mail

40. Electronic mail (e-mail) enables person-to-person communication via messages consisting of text, voice and some graphics transmitted to other computers connected within a network. Messages arrive instantly in the electronic mailbox of the receiver's computer and remain until they are read, deleted, printed or forwarded. This requires subscribers to regularly check the in the electronic mailbox as with a normal mailbox. It is a fast method of communication between individuals and groups because it is time and place independent and, as with writing letters, the documents can be keyed off-line and then downloaded and sent across a network during the night when telephone rates are less expensive. Besides the computer and printer, the total cost includes a modem and its connection cables, a communication software, the rental of a dedicated telephone line, a registration fee for a mailbox and e-mail network access, as well as the telecommunication charges (for a given destination and length of time rates are the same as for a telephone call).

Bulletin board systems (BBS)

41. A bulletin board system is a computer-based communication system that allows users to send and receive messages or data files to and from a server or other users. BBS can offer several services:

- e-mail (see above);
- bulletin board messages for special interest groups;
- question and answer services from and to users;
- access to public domain software, computer games and contests

42. Globally speaking, the main purpose of the BBS is to offer information-sharing services for special interest groups and a sort of open forum (teleforum) where people meet, communicate and debate informally at a distance. User cost is about the same as for e-mail.

Computer conferencing

43. A computer conferencing system is fundamentally a BBS, but with a different organisation and working method requiring a specialised software on a server. A computer conference is, in principle, not public but organised by a facilitator on a given subject for which a number of interested persons are invited through personal contacts before the start of the conference. Participants have access to all the communications sent in by the other participants and can, in turn, respond to what they have read with a message.

44. The main interest of a computer conference is that the participants do not have to be at the same place at the same time, which can save travel time and expense. For educational purposes, it can also provide convenient, potentially 24-hour, access to course material and (eventually) access to a distant expert as well as an enhancement of group interaction opportunities.

45. The direct cost for a participant is of the same magnitude as for e-mail but much more expensive for the organiser. A participation fee is sometimes requested from each participant (as in any other conference).

Information retrieval

46. Books, journals, articles and various other information sources are more frequently put into electronic form (stored into computers) either as catalogues or indexes or as full text for easier retrieval and access. Some academic institutions, private companies, book publishers, etc. have set up specialised databases whose access is either free (many academic electronic libraries) or on a cost basis.

47. The design, implementation and maintenance of a database is very expensive and time consuming and is generally viable only if there is a large number of users. The easiest way to increase this number is to allow access to the database at a distance by putting the it on a server connected to an international computer network. In fact, the two main roles of international networks are e-mail and distant database access.

Multimedia

48. The convergence of computers with telecommunications is leading to a situation where the computer (connected to a network) becomes a device for information retrieving, receiving, storing, displaying, processing and forwarding irrespective of the form of that information (text, graphic, sound, voice, pictures, video, etc.). The computer is thus progressively taking over the roles of the mail, telephone and television, with a number of improvements because of its capacity to store and process information before displaying or sending it out. The computer has become a multimedia device.

49. The digital storing of sound, pictures and video requires disks of very large capacity. Without compression, one colour picture in standard 640x480 definition needs 2.5 megabytes and one second of high-quality sound needs 0.7 megabytes. To store a reasonable amount of text, pictures, videos and sound on a single disk, a capacity of about 1 000 megabytes would be necessary. However, for physical reasons,

this is not achievable on a standard magnetic disk. The problem has been solved, therefore, through the use of a laser beam which reads the data on a disk (sometimes called an optical disk). For commercial reasons, the disk has been given the same 12 cm diameter as the well-known audio compact disk (CD). With this diameter, the capacity of the disk is about 550 to 600 megabytes, which allows the storage of one of the following or any mix up to 600 megabytes (using data compression) :

-- 500 000 pages of A4 text;
-- 20 000 standard pictures or 5 000 high-quality photographs;
-- one hour of high-quality stereo sound;
-- one hour of full-motion video.

Optical disks come in two main types: Compact Disk Read Only Memory (CD-ROM) and Compact Disk Interactive (CD-I).

CD-ROM

50. The compact-disk-read-only-memory is a storage device where information (text, graphics, audio and video) is stored in digital form. A CD-ROM drive attached to a microcomputer is needed for accessing the information. Recent models of CD-ROM drives are also able to read audio CDs.

51. Like audio CDs, CD-ROMs are manufactured by pressing, and their price (at least for those produced in large numbers) should therefore, in the long range, be of the same magnitude. Even now, at their rather high price (between $50 and $150 and up to $1 000 depending on the content) they are already much more economical per byte than all other high-capacity digital storage media. Therefore, they are a privileged low-cost delivery medium for large amounts of multimedia data. A considerable amount of information is already available in CD-ROM form such as journals, world-wide picture collections, encyclopaedias, dictionaries, various static databases such as library catalogues, educational multimedia software, games, etc. Over 3 000 titles were available at the end of 1993.

52. Since CD-ROMs are computer read-only storage devices, their content cannot be modified. However, the information available on the disk can be loaded in the computer's memory and modified in any way by the user for his or her own purpose and then stored on a read-write disk for future use. For example, a colour picture can be downloaded from a CD-ROM, part of it extracted, changed in size or colour, pasted into a text currently being typed and printed later (provided there is no copyright!). This is not the case with the other type of optical disk known as Compact Disk-Interactive.

CD-I

53. A compact disk-interactive is not physically different from a CD-ROM. However, there is a difference in the way it is used. A CD-I drive is a complete stand-alone unit which includes a microprocessor and the relevant software, and it has to be connected to a television set. It is interactive in the sense that the user is able to access any part of the disk at any time and, as with audio CDs, can also specify which parts should follow each other. However, contrary to a CD-ROM, no part of the content is accessible for modification and recopying into another document, so that, in fact, it is not any more "interactive" than an audio CD. Because of the way information is organised, videos run more smoothly on a CD-I than on a CD-ROM, and a recently developed add-on device allows the storage of a full-length film with sound on a CD-I. CD-Is do not run on a CD-ROM drive.

Concluding remarks

54. Rapid advances in computing and communication technologies are making a reality of many visions of the future which, when postulated, once appeared unachievable. Apple Computer's vision of the future of academic computing, for example, was shown in the video, "The Knowledge Navigator". Although this very futuristic video of a typical day of an academic in the year 2004 was produced back in 1987, many of the technologies featured in it are now already available in 1994, including those of computer and human interface (handwriting and gesture recognition, speech recognition, intelligent assistance, text to speech and speech to text), information retrieval and videoconferencing.

55. This brief introduction to present-day information technology was intended as a guided tour of the available technology and the way it works. Little was said about its use in education. A guided tour of the educational use of these tools and the relevant software is the subject of the next chapter.

Chapter 1

The Present Situation

56. The title of this report is "The Future of Technology in Post-Secondary Education". For the purpose of understanding the intersection of technology and education, the title could be flipped to read "The Future of Post-Secondary Education with Technology" or "The Future of Post-Secondary Education without Technology". These alternate titles posit very different visions of the future of education, but these opposites are developing simultaneously. The present situation of technology in education has some high points in terms of applications and locations that are technologically advanced, but the majority of the educational establishment has been slow to adapt technologies.

57. Lack of funding, inadequate training, inappropriate software and scarce equipment explain some of the hesitation, but not all. There has been a reluctance to change, an expectation that the methods of teaching and learning that have existed successfully will continue to do so. But the pressures and demands on post-secondary education are evolving as students, employers and governments look at the economic, demographic, societal, and technological environments of the present and the future. The use and the impact of technology, as discussed here, is only one facet of this challenge to education. This chapter will address the current situation, partly by way of detailed descriptions of applications, but also in terms of the present context and attitudes towards technology in post-secondary education.

58. Post-secondary education cannot be defined simply as the education offered by universities, colleges and technical institutes to young students on their campuses. The population has been changing to include many older students, part-time students, and those who study far away from the campus, whether in a geographic or practical sense. Community education may provide credit courses or the more informal study circles and continuing education courses. The provision of training in industry may be termed a growth industry, with estimated expenditures between $50 and $200 billion annually in the United .States. alone.

59. Various forms of post-secondary education have adopted technology in ways that fit their needs and resources. The home, workplace, school and community learning centre have become settings where adults use old technology such as print, audio and video -- or new technologies -- such as computers and multimedia resources--for their professional, academic and personal improvement.

60. According to Alan Thomas," No country in the world that I know of can report with any accuracy its level of expenditure on the education of adults. All seemed to have developed mixed systems of provision." In the wide universe of adult learning at the post-secondary level, the expenditures on technology are even more obscured. Some countries, regions and institutions have invested enormously in experimental and long-term applications that have met with various levels of success. The Canadian government invested millions of dollars in the Telidon videotex system, including the development of educational usages, only to find that neither the technology nor the market were prepared. The

development of hardware, software and training to support PLATO has proved more beneficial as the system is still used in a number of places and learning situations.

61. Initial investments have often been made at the secondary and primary level with the post-secondary institutions becoming involved for teacher training, research and software development. The Dutch programmes of the mid-80s emphasised hardware and teacher training for secondary schools, but university subject specialists were also involved in investigating the use of computers and information technology for their subjects. This project was sponsored by IBM and Philips, who offered to supply the hardware for schools and aid in the provision of teacher training and software.

62. The French government launched a programme called *Informatique pour tous* in 1985. Over 100 000 microcomputers were installed in schools, colleges and universities. Courses of various lengths were given to explain the computer as a learning and teaching tool, for programming, word processing, information retrieval, database access and computer-assisted learning. The programme was seen as successful in training large numbers of instructors, but the actual integration of the computer into classroom practice did not receive adequate attention. Thus, while capable of using the computer, teachers were not well equipped to teach with it. Numerous other countries have had similar experiences in national plans for the introduction of technology in education.

63. Although the investment in technology for education is difficult to estimate, UNESCO has provided figures on the scope of post-secondary education internationally. In 1990, 63 million people were participating in post-secondary or third-level education. Of these, 35.4 million were in the developed world (as defined by the United Nations). In second level education there were 299.8 million students and 610.9 million in primary or first level education world-wide). Over four and a half million teachers were employed in post-secondary institutions. The public expenditure on education in 1991 was $1 119.1 billion, of which $951.1 was in developed countries. An average of $2 580 was spent per student at the third level in developed countries. As these figures include only public expenditures and only institutional education, the reality of the investment is even larger than these figures indicate. Education is clearly one of the largest activities of all governments, with enormous investment in dollars, human resources and gross national product for every nation. It is the very size of education that makes it a target of so much attention in this time of economic transition.

64. The role of education has traditionally been to prepare students to live and work in their society. However, the ways of work are radically changing, partly due to globalisation of economies and the use of technology in workplaces. In response, post-secondary education must not only modify the content and intent of what is being provided but also the way in which teaching is offered.

65. In North America there are clear signs that education has become a competitive business as private interests have set up networks and institutions offering degrees, diplomas and professional training on their own or in co-operation with universities and colleges. Governments are looking for ways to reduce their spending, and education budgets are a large part of this expenditure. The private sector recognises the huge potential of the education market, especially as a part of the technological networks that they are establishing. In Europe, Asia and North America, the satellite, cable and telephone companies are building capacity through fibre optics and digitisation and are talking of the 500-channel universe.

66. As another part of this scenario, the need for training, retraining and enhanced education has become intrinsic to government policy, industrial planning and citizen demands. These demands for services and skills and the expansion of the technological capacity can be seen as providing enormous potential for

post-secondary education. Many institutions have been working in this new context for many years, others are just beginning and others yet recognise the opportunities but are uncertain or reluctant about their involvement.

67. In post-secondary, formal education, computers were first introduced into mathematics and physics departments of universities where they were used mainly for research. The advent of the mini-computer in the mid-1960s, with a corresponding decrease in price and the invention of time-sharing which made interactive computing possible, led to the first commercial applications of technology-assisted instruction. For example, the PLATO project, TICCIT project and the IBM 1500 system all started in the late 1960s. The cost, however, remained high and so the computers were restricted to research or the teaching of computer science itself. The first microcomputers in the late 1970s were not powerful enough for post-secondary education and it was not until the next decade that they began to be used. Although their integration has been remarkable in the last ten years, few would consider it adequate.

68. Aside from the lack of resources which has plagued the introduction of a critical mass of computers and software that would allow appropriate and widespread use, there have been attitudes, methods of planning and organising and funding of post-secondary education that have hampered widespread integration. Even when the technology has been put in place, its full potential has rarely been exploited.

69. Much of this use of technology has been the *reproduction* of current practice, whether lectures, experiments, discussions or other ways of presenting information. This is the standard beginning for the adoption of any new technology--the replication of traditional approaches using new methodology. The next stage is *innovation*, in which the technology leads to new ways of teaching and learning or supporting the administration of education. This may be the realm of the newer interactive technologies, such as networks and multimedia, and the growth of distance education, that links the learner with the institution by technological means. The final application of technology is the *transformation* of education making it into something that is different in content, purpose or traditions. This may be the more futuristic vision of individual learners all over the globe interacting to create and share knowledge with or without the existence of educational institutions as such. The seeds for this transformation may already exist in the technological capacity, but the societal and economic supports have not yet been developed.

Current practice in the use of information technologies

70. The majority of the technologies that are outlined in the introduction have been successfully applied to post-secondary education teaching or management. The stories of these uses and why and how they worked are essential components of any change across the system and in encouraging innovation rather then substitution. The examples given below are provided simply to demonstrate that there is important activity that can advise further and more creative development.

Video broadcasting and conferencing

71. Video broadcasting has been adopted in many countries predominantly for distance education, the bulk of which is lecture-at-a-distance. A single instructional source is broadcast to multiple remote learning sites. The dominant technology used for this is satellite, as it is estimated that over 4 per cent of American schools have a satellite down link. The second most common technology is cable television whereas the telephone network is the least used, tending to be private lines rather than standard public, switched

facilities. The challenge for distance education has been to provide the interactivity that students need for effective learning and so the use of telephone technology has been expanding. This may be to supplement one-way video, for teleconferences or for delivery of voice, graphics and data.

72. Both pedagogical and technological factors are driving the future video conference in post-secondary education to the desktop. Most influential among the technological factors are developments in hardware and networking. Next generation PCs will include video, audio and coder/decoder technology. By 1997 close to 70 per cent of US. telephone customers will be served by ISDN switching technology. A significant amount of videoconferencing traffic can be carried by basic-rate ISDN (128 Kb/sec) and the primary rate can carry 1.5 Mb/sec. Student will be able to interact with each other and will have synchronous interpersonal interaction with experts. The learning environment can become more student-centred and tasks and projects become the learning focus rather than the teacher and the lecture.

73. An example of the application of telephone technology has been developed at the University of Ottawa in Canada. Both voice and audio graphics are used to deliver a class to remote sites that is being delivered on campus at the same time. Therefore, the interaction is in real time and the remote students are brought together in distant classrooms. The equipment is easy to operate so that technicians are not required. The equipment and the teaching are cost-effective and the student results are equivalent to those of the on-campus learners, but adapting classroom pedagogy to distant learners has proven more difficult than expected.

74. In another application of a sophisticated telephone and computer technology, Maritime Telephone and Telegraph in Nova Scotia developed Network Nova Scotia in partnership with the provincial and federal governments, Northern Telecom, Worldlinx Telecommunications and Compression Labs. This custom designed network provides audio, data and video links for remote lecture capacity with interactive communications to and from teaching locations and multiple remote learning centres. There were 28 voice, 28 graphic and 7 video access links at the headquarters. With 14 universities and numerous colleges, this network is an important part of the educational strategy for the province. The operating charges that were published in 1993 were $4 200 for voice, $4 200 for graphics and $16 500 for video network access per year. This is the first multipoint, multimedia educational network based on international standards for conferencing in the world.

75. This visual teleconferencing allows the sharing in real time of images that may be seen and changed interactively. The image can be created using a computer graphics package or brought into the system through a document scanner or through a video input source such as a VCR or camera. The University of Alaska set up a pilot network to test the technology as a teaching tool with village students and their teachers. The results indicate that both the student and teacher responses have been good, with motivation enhanced by the interactivity and the strong visual component.

76. At the University of Illinois at Urbana-Champaign this technology has been used for horticulture, food science, educational psychology, engineering, social work, animal science and special education. The professors find that the preparation for these classes requires more time but that the visuals are high-quality and effective and that graduate courses in numerous off-campus locations become economically feasible. The university has also used this technology to reach a new constituency by providing upgrading courses to the aeronautical engineers at McDonnell Douglas at their workplace.

77. Hewlett Packard has developed its own videoconferencing system that delivers training to more than 110 corporate training sites. According to their calculations, the courses that they offer through this network would cost $5 million in face-to-face mode and have been delivered for only $750 000 at a distance. Video conferencing is being used by over 15 per cent of the larger United States firms that have multiple branches around the country. Many of them rent their own transponder on a national satellite in order to provide training, employee communication and some management applications.

78. In a more administrative but extremely popular application of technology, many universities and colleges in France (Ravel System) as well as in Canada have instituted touch-tone registration with voice mail technology to allow students to register for, drop or change courses. When the University of Quebec at Montreal put students' final grades and grade point averages on this system, they received up to 8 000 calls a day.

79. Much of Canadian educational television works through satellite. The Saskatchewan Communications Network has a training network that reaches 90 sites in the province in regional colleges, high schools and other institutions. Over 50 live courses were delivered in the 1993-94 academic year, including credit courses from the universities and colleges. The Saskatchewan Indian Federated College broke new ground by transmitting an Indian language degree course, Ojibway 100, to a number of reserves in the province.

80. In 1991-92, the educational broadcasters in Canada had combined budgets of almost $200 million to provide over 35 000 hours of television programming for learners of all ages. Post-secondary education is well served through the broadcasting of credit courses, programmes on studying at a distance, debates on the issues and future of education, teacher training materials and seminars, and information on courses and institutions. In addition, the Open Learning Agency in British Columbia and TV Ontario have been working with professional associations, industry and government to develop training packages that respond directly to the needs of the workforce for new skills and credentials.

81. Industry has also taken on its own development of essential software. For example, a 16-module multimedia learning system has been developed on Swiss banking for independent and group study by apprentices with case studies, games, competitions and simulations. The first module was completed in October 1993 and the full package is expected by the end of 1994. Ernst and Young is also implementing its first multimedia, interactive programme to train auditors world-wide. Tests have shown that this approach reduces course completion time, statistically, by 50-60 per cent and test scores are higher and more consistent than with classroom training.

82. The above examples have used words such as interactive and multimedia abundantly. These are keys to success in technology in adult education. Each of the above is also expensive, extensive and took industrial, government and/or educational co-operation to accomplish. This scale will be difficult for most educational institutions and governments with limited resources and industries that are struggling to survive. But progress has been made and the promise remains.

The use of computers for teaching and learning

83. In many cases, particularly when tutorial software is used, the computer is the most accessible and easy to learn of the new technologies. But commercially available software often does not meet the instructional needs in a content sense of the vast majority of instructors. Teachers also have had very little

opportunity to become comfortable with the technology and may be faced with students who are more literate than they themselves are. It should be kept in mind that those under 18 in the OECD countries do not know a world without the computer.

84. Many instructors have found their comfort level with technology in communications, in electronic mail, bulletin boards and networks that connect them with their colleagues on and off campus and around the world. Starting with simple messages, they have progressed through the exchange of research to the joint development of papers to the "virtual research centres" that have been created through networks such as Internet. In this, ongoing research is shared so that all may test and contribute to the development of theories and results. Direct course delivery is also available using electronic bulletin boards and e-mail. For example, Queen Margaret College in Edinburgh delivers a degree course in communications in this way.

85. Students have also been able to gain access to computers as many institutions provide equipment in common areas. These are used most for document preparation but may also be employed for searches or for instructional software. The on-campus student is more likely to have benefit of these micro computers, while the distance education student may have access to a much wider range of technologies in the local learning centres. The most extensively equipped of these centres are furnished with VCRs and monitors, satellite receiving dishes, teleconferencing technology for voice and data, microcomputers and, in some cases, even CD-ROM and videodisk players in experimental applications of these technologies.

86. Although the results of research give an incomplete and impressionistic picture, by and large they support the view that computers have considerable potential to enhance teaching and learning. This is happening in many different ways. Firstly, it is happening through the need of all students to become computer literate, that is, able to handle current information technology at a level appropriate to their discipline and be equipped to continue their development with it into the future. By the 21st century, students who are not computer literate will not be considered fully educated. When students have access to computers and know how to use them, they will introduce this skill into all areas of study, thus transforming their way of working.

87. Secondly, many disciplines and professions require a deeper understanding of the information technologies. These include not just the traditional "hard" computing areas such as computer science and information systems and the various branches of engineering and the sciences where the object of study is computing or information technology itself, but also the "softer" computing areas such as the social and health sciences, business and education where the emphasis is on the use of computing or information technology as a tool. Examples include the engineering student learning design with CAD-CAM stations, chemists working with molecular modelling tools and computer controlled sensors and accountants working with integrated database and spreadsheet packages.

88. Thirdly, computers are used to mediate or manage the teaching in the form of tutorials, practice sessions, assessments, simulations, multimedia, etc. Although the development of the courseware and the application of software to teaching to enable this to happen is time consuming, such use does offer many advantages: conventional tutors need not be present and students can work individually or collaboratively at their own pace. This takes a number of forms.

89. Information technology can be used to improve the teaching and learning environment by providing easier and more efficient methods of preparing course materials. The availability of word processing, spreadsheet and graphics packages means that teaching staff have access to convenient facilities

for the preparation of course material such as lecture notes, reading lists, project specifications, tests and examination sheets, tutorial handouts, and overhead projector transparencies.

90. Information technology can be used to improve the methods of classroom delivery of teaching material. The current main method of imparting knowledge to students relies heavily on lectures, tutorials, and practical classes and the principal impact of technology on teaching has been the use of the overhead projector and transparencies. There has been an increasing use of video but only very rarely is a computer used in the lecture theatre or classroom.

91. Computers can be connected to appropriate overhead projectors by means of a data show so that students can be shown output from the computer in real time i.e. as it actually happens. Output might be the results of a computation or information retrieved from a database, a simulation of some physical system or simply the graphical illustration of some point which is being discussed in the lecture. Videodisks under computer control can be connected to the lecture theatre projection system, allowing the retrieval of full video sequences and still images.

92. Information technology can be used to improve the management of learning and assessment procedures by teaching staff. On an individual basis, lecturers can use spreadsheets, databases and statistical packages as aids in the management of their classes. A system such as Computer Managed Learning (CML), which was used by over 8 000 students in 1993 at Curtin University (Western Australia), allows an even higher level of management of the learning process by the many features of the system. A typical user is the Department of Human Biology which has some 800 students, including external students, who access the CML unit on a regular basis each semester. In this way continuous assessment is carried out, offering instant feedback on student progress. This has become an integral part of courses in many countries, providing a management component which does not incur more staff time and frees up teaching staff from the tedious marking of tests.

Computer-based learning

93. The use of computers for instruction or computer-based learning including devices such as videodisk and CD-ROM, allows teaching to investigate new fields and explore old more deeply. New activities and topics which can only be treated because of the advent of the computer can be and are being included in existing subjects. Simulation packages allow the modelling of other environments and experiments in the physical and biological sciences and offer students types of activities which were not possible before. In the case of statistics, alternative tests can readily be made and compared. Drill and practice and tutorials can have their place. The use of technologies can be integrated across disciplines.

94. Examples can be given of ways in which the use of the computer can bring about changes in how students learn and teachers teach. A number of studies, for example, have shown that students feel positive about activities using the computer and that they experience a sense of independence when working at the computer and satisfaction in their ability to control the technology. Observers report a higher level of motivation in students working at computers and increased and enthusiastic collaboration among students involved in co-operative activities. Students learn more using computers. They also learn more quickly.

95. The use of computer-based and computer-managed learning is well established in many universities in the United Kingdom and in the United States. In the United Kingdom, for example, the use of computer-based learning has been encouraged by the Universities' Computer Board by means of the Computers in Teaching Initiative (CTI) and the Teaching and Learning Technology Programme (TLTP).

which have been responsible for the development of tertiary-level courseware across a wide range of disciplines and for the continued support for computer-based learning through the establishment of over 20 university-based CTI centres providing support and information for individual disciplines.

96. Examples of computer-based learning include the use of computers interfaced to MIDI keyboards for sequencing, publishing, and teaching composition in the study of music. In design work, sophisticated packages are being used with students to ensure they are aware of and can use the leading edge of technology in the area of art and design. Packages such as DYNAPERSPECTIVE, which teaches students concepts of 3D space as well as the benefits of computer use in a three-dimensional environment and INFINI-D, are used for producing photo-realistic product designs for presentation and prototyping. In many institutions students study physiology by means of simulation packages.

97. Statistics and mathematics are among the areas where the use of computing has been successful, some authors even claiming that they cannot be taught well without an integrated use of computers. Examples include the use of powerful graphics-oriented packages such as MAPLE, MACSYMA and DERIVE in the mathematics curriculum. This use not only enhances the pedagogical style used in teaching concepts but has also altered the mathematical ideas and methods covered in the courses. In calculus, for example, students spend less time on such things as compulsory integration and differentiation and more on basic concepts which are taught and studied from a graphical perspective.

Use of networks

98. The rapid growth of international networks, such as Internet, provides revolutionary new options for using information to fundamentally alter both curricula and pedagogy, giving students access to information world-wide anywhere and at any time. In this respect the developments in the use of electronic mail, computer conferencing and electronic bulletin boards, loosely referred to as Computer-Mediated Communication (CMC) make the world of the "net" open to groups ranging from children to senior citizens for educational and training purposes ranging from psychological counselling to engineering, by organisations ranging from colleges and universities to businesses to local community organisations in every continent.

99. Library automation, which emerged initially simply as a means of managing the operations of the university library, has leveraged the original intent by extending access to rich sources of bibliographic information in support of teaching and learning and the provision of access to any information, any time, anywhere.

100. Internet makes real-time connections possible between thousands of computers and enables their resources to be available to anybody accessing the network. Examples of Internet sites whose resources are available include: SpaceLINK, which provides a database and interactive system containing information about NASA and NASA activities; over 1 000 academic and research libraries, whose catalogues can be searched; TC Forum, which provides a clearinghouse for educational information, instruction and communication. Many of the services available also provide interpersonal sharing of information and news long before it is published in the more traditional media.

101. Some Internet sites provide gateways to other sites offering information of a similar type. Thus, for example, many European and Australian universities give access to their own library catalogues and provide a link to other libraries in their country and through a gateway to many US and international electronic library catalogues. The potential benefits of the Internet include allowing the teaching and

research community, as well as on-campus and flexible or open learning students, to participate in discussions, exchange documents, information and data with their peers throughout the world and to access virtual libraries at minimal cost. It allows instructors to incorporate world-wide information sources into courses and, in doing so, has the potential to change the way in which courses are offered.

Databases and libraries

102. Databases and libraries have become tools for both students and instructors in new ways, as the resources are more available and easier to use than ever before. The variety of materials that can be included in databases is no longer restricted to published articles and referred works. Instead, a network allows all to take part in a discussion and to put forward opinions and present papers that may not have passed the rigours of academic review. This has both strengths and weaknesses in democratising teaching and learning, but it does modify the traditional legitimate methods for the creation of knowledge. At this point the application of technology moves into the transformative stage referred to earlier. Despite the popularity of Internet, *transformation* is not yet the reality of technology in post-secondary education.

Concluding remarks

103. A perusal of the literature reveals a number of complaints and concerns that were evident ten years ago in studies and reports on technology in education. This is not to deny the progress that has been made in some places, for some learners, in some programmes and institutions, but it shows that the inherently conservative nature of education persists. The essence of education is not seen to be changing, despite the technological promise. At best, instructors and institutions are using technology to replicate their practice, their content and their control. The relationship between teacher and learner; pedagogical strategies; control by the institutions; structure, time and place of learning; those who are best served by the system; the direct practicality of learning--have not fundamentally changed or even been seriously challenged by the new societal, technical and economic realities.

104. The influence of technology on schooling, learning, teaching and educational organisation has not been significant across the range of post-secondary education. What is more, little is understood of how change in one of the areas listed in the preceding point would impact on the others, i. e. how the increased student control of learning made possible by technology would influence the role and organisation of institutions. Taking this a step further, there are changes in society that will result from each of these changes separately and in tandem. The educational infrastructure reconfigured in its power base will most probably have ramifications for society as a whole. This is not to forecast a "brave new world" brought about through computer networks, videoconferencing and other technologies, but to stimulate a consideration of the possible consequences of technology in education. They may be more modest than a new world order but they will certainly be more dramatic than the current situation indicates.

Chapter 2

The Possibilities

105. The possibilities themselves can be viewed as revolutionary or evolutionary and the process of change can be categorised according to these same terms. The time frame in which consequential or massive change can be expected in different jurisdictions depends on factors that are far outside the technologies themselves. While technologies are not without their inherent values, it is the change in attitude and practice, in the ownership of education, in the linking of work and study into lifelong learning that is supported by government, industry and society as a whole that will implicate and exploit technologies.

Pedagogical content

Implications for learning

106. The model of one teaching many as in the standard classroom and distance education course can progressively become the many teaching one or the many teaching many. Students may choose databases, other students, networked instructors and discussion groups, tapes, exploratory learning, or whatever methods fits their learning style, what they need to learn and the available resources. Access is not limited to the resources of a campus or an organisation but is enlarged to all international networks. Technology challenges the idea of the regulation of learning. The number of hours a day, the location, the resources, the learning group are no longer dictated by the institution but by the learner. Students can begin to create their own databases and to add to and modify those being developed elsewhere. As suggested in the previous chapter, the control of knowledge and its creation will be more diffuse.

107. The availability of multiple sources and resources may also permit learners with special needs to receive equitable educational opportunities. This group could include rural dwellers, the handicapped, or those without the financial or other resources to attend full time. This of course supposes access to the technology itself and the ability to pay or have subsidised the software, connection and other associated costs.

108. The future of technology-assisted education will depend on the application of new approaches enabling an ownership of computers far greater than at present and for these computers to be interlinked and become connected multimedia processors. This will liberate education from time and place restraints as well as free students from the learning style demands that have previously been made on them.

109. Taking notes at lectures, performing or observing live experiments, the separation of the classroom, the assignments and the application of the learning -- all can be replaced and, in some cases, improved on. Simulation software and exploratory learning through electronic and hypertext databases and videodisks can provide models, experiments and challenges that are impossible in other situations. Rather than listening to a lecture and expanding on the ideas later through reading, the learner can move through a database and follow up intriguing concepts in more detail immediately. Moving over electronically to a simulation or a case study, the student can apply this information or theory and observe the results.

110. This description assumes unlimited access to resources and a highly independent, motivated and competent learner. While not a miracle in itself, technology has been known to motivate and hold learners as they move at their own pace and through their own interests. Much has been said of the individualisation that gives permission to fail and try repeatedly, but research has shown that once the allure of the technology itself fades, the power of the learning and the resources do keep most students involved and progressing. In many cases the work with technology implies student motivation and satisfaction uncommon in other forms of learning. Students become more independent and more empowered in their learning.

111. According to experience in Denmark, the basic way in which education and training are taking place is through *dialogue* between students and teachers and students as a group. The ideal is the simultaneous oral dialogue in a social environment where it is possible to interpret both the spoken word and body language. A small group of ten to twelve students and a teacher works best. The problem with distance and technology-based training in the forms that have been used to date has been the lack of this flexible dialogue. The use of the telephone can compensate for this to some extent but it demands synchronous activity, often impossible in distance learning situations.

112. The solution in most cases has been to reduce the need for dialogue by attempting to put all the necessary information in the print or electronic sources, usually textbooks. Study centres were set up to deal with the still unanswered questions. The production of these resources was very detailed, lengthy and costly, demanding extensive reviews by instructors and students. To amortise this expense, the book or video had to have a long shelf-life and high course enrolments. This has been the model used in many open learning institutions around the world.

113. Networked computers are able to modify this by opening up the possibility of classic dialogues. In fact students may begin answering many of the questions for the other students in a dedicated computer conference, managed by the teacher. However, the bulk of the course is not put in the computer conference, but meetings that may last two days every six weeks are set up to convey essential information. This is not the same as the use of the study centre to answer specific questions but a part of the course offering itself.

114. The advantage of this model from an economic point of view is that it is much cheaper and faster to produce the course materials. The network can be used to send additional documents, bringing the production process closer to the just-in-time education that can happen face-to-face. With computer-based learning and multimedia courses, production again demands that all possible information be put into the resources. But because of the new technologies, this can be done more effectively than in the traditional linear technologies. In some cases it is so well done that the students believe they are in a real dialogue with the machine.

115. Many of the interactive resources may have been developed for distance education, but learners in universities, colleges, workplaces and other more traditional settings will also use more interactive self-study material. Not only will computer-equipped students become masters of their own learning, but traditional teaching will become too expensive and the small seminar class less frequent. Large lecture halls and students taking advantage of electronic resources are more likely to be the scene of the future. As more traditional universities and technical colleges become involved in technology-based distance learning, they will become more willing to adapt these materials to their on-campus courses. The costs of the development and the pressure of the students are persuasive arguments for the integration of technology resources.

116. Thus, the production methods that have characterised traditional education will be affected by the economic realities and the new industrial experience. The computer and networks are part of the new environments that will impact on education.

Implications for teaching

117. A substantial portion of education is spent on training students to memorise facts, methods and techniques through more or less sophisticated drill and practice activities. Many of these do not require the presence of an instructor and could be done by students on computers. Some of the exercises do not even require the physical presence of the students in the classroom as long as they are able to obtain the resources from the central server and have access to a help line. Research has shown that, provided the exercises on the computer are well designed, they can encourage more autonomous attitudes and more creative thinking than the classic pen and paper exercises.

118. This new organisation of teaching also implies a change in content. Time spent teaching facts, figures, methods and techniques can be reduced and, instead, time can be devoted to the more cognitive questions of who, how, and why. Courses can become "meta-courses", meaning they will emphasize the foundations, concepts and ways of thinking rather than content. For example, the way that historical analyses look at the world and how they intersect with the economics, geography, medicine, literature and fashion of a given period and location could be explored with each student of history through use of a computer and other technologies such as video and maps on CD-ROM, which then can be integrated to demonstrate the confluence of ideas. Subjects and learning may be far more interdisciplinary as the organisation of knowledge changes and the convergence of technology allows the integration of various resources.

119. The demands that this would make on an instructor are obvious, as subject specialisations would become less rigid and interrelationships more crucial. The perspective may remain historical or biological but the information encompassed within the perspective would expand. The manner in which a subject could be taught and learned would resemble the best database rather than a textbook. The movement would not be linear--through a knowledge base from simple to complex or ancient to new--but interactive, following trends with more or less attention to detail, cross-checking, and circular or spiral patterns. This does not obviate the instructor's role, since guidance must be provided to ensure that exploration does not become a voyage to nowhere. The when and how of this guidance can also be technologically designed but the importance of the dialogue must not be ignored.

120. Technology offers the opportunity for instructors to learn something from their students, as many of the new generation of students will be entering post-secondary education far more technologically literate than their instructors. This in itself could influence the balance of power in education.

121. Thus, it is recognised that what technology can bring to education is not simply a few changes in procedures, but a radical redefinition of the way in which the post-secondary institution functions in relation to students, instructors and information. The control of information, the dialogue, production of learning materials, and the organisation of subject teaching have been examined to demonstrate how the thinking about the applications of new technologies leads to new concepts of post-secondary education. Whether the integration of technology is seen as an evolution or a revolution does not change the reality that education will change--and these changes should preferably be determined and to some extent controlled within the institutions or they will be brought about by external pressures. The option that things will remain unchanged is not available to students, instructors or organisations in post-secondary education.

Educational environment

122. Changes that may occur in institutions include fewer students on campus, more part-time students, more adult learners who are in jobs or career change, lower funding levels because of different requirements for infrastructure and service, and higher student/faculty ratio as the students become more self-sufficient or linked to many more sources at the same time. Changes in the production and supply of teaching materials and opportunities for extensive partnerships for the development and delivery of resources with a less exclusive universe for educational institutions are also factors of the new environment.

Institutions without walls

123. Over the last twenty years, library automation has become a topic of increasing importance in post-secondary education in general and in universities in particular. The movement towards on-line delivery of electronic library resources is of great importance since it makes the use of computers equally crucial to students in the arts and humanities as to those studying science and technology. The initial intent of libraries to reduce cataloguing costs and achieve consistent bibliographic control have led to ever larger catalogues and to access to indexes, abstracts, and to the great collections of the world. The ultimate goal is to provide access to information any time and anywhere, to create "libraries without walls."

124. The concept "without walls" can be extended to the institution as well, as schooling at home and in the workplace and community becomes more accessible and more comparable to the supportive environment that can be found on campus. Many adult students enrolled in post-secondary education are in search of specific skills, credits and degrees. They are not looking for the same social and nurturing environment as students who have just completed secondary school. Although many of these adults may need study skills and career counselling initially, they then become more independent and look to the educational institution strictly to supply the course and credential that they need. As the part-time adult population in education grows, technology can be decisive in filling their needs, and much of the other support that campuses supply becomes less necessary.

125. The "university without walls" and the "college without walls" give way to the concept of open learning. Here, the methods of distance education and technology-aided, individualised learning are tied to the idea of open access to institutions. The ability to start and complete courses regardless of institutional schedules, easy transfer of credits between institutions, credit for previous life experience, and other innovations, are part of open learning and technology plays a crucial role in all of them.

Publishing

126. Desktop typesetting and fast laser printers are already modifying the relationship between the post-secondary educational institutions and book and journal publishers. On the one hand, some faculty members are questioning the present process whereby they give to publishers their papers containing the results of their research (usually paid for by the university). These same publishers then sell these and others, printed on high-quality paper, back to university libraries at prices that are often beyond the capacity of the individual instructor. Proposals to publish research papers in "electronic journals" are confronted with problems of peer review, date of first publication, quality of the journals and the other essential characteristics of academic publishing. On the other hand, there are co-operative initiatives such as that between McGraw-Hill and the University of California, San Diego, to customise textbooks in real time to meet the increasingly specific needs of faculty and students.

127. This second option opens up the thorny field of copyright and payment to authors, editors and publishers for chapters and excerpts from books that are then assembled in "textbook packages". The supplying of electronic textbooks on demand will also change the nature of the instructional book market. It is estimated that an $80 textbook can be replaced with $20 worth of software and a package of assembled materials. However, the development costs of the software are substantial and the fluidity of the market demand does not ensure an adequate return. The capacity of the technology is confronted with the reality of the market place in educational publishing.

128. Many publishers have been converting their materials to disks, some on their own, while others have contracted this out. In the October 1993 issue of *The Economist* (p. 91) quoted industry analysts' predictions that by the year 2000 up to 40 per cent of the turnover of the publishing industry as a whole will be electronic products. Much of this is expected to be in the fields of education and reference where the storage capacity and interactivity of electronic books are most valued.

129. Many dictionaries and encyclopaedias in various countries can be found on CD-ROM and combine sound, visuals, graphics and text to present information in an engaging and informative and attractive format. Using one of these CD-ROMs, students can listen to national anthems, to basic phrases in 60 languages, use a dictionary, thesaurus, word-processing programme, tour cities and countries and prepare their own multimedia presentation. While still expensive, the mass market appeal of an encyclopaedia makes this investment possible, but certain academic experiences could also be provided through this medium.

130. One of the impediments to development of a psychology disk or history disk is the "not invented here" attitude where some academics tend to resist what they have not developed themselves. This is another example of how technology challenges the instructor's relationship with the student and the knowledge. Approving a textbook for general usage is quite different from relating to students who have used disks and databases in their search for information. This is not only quantitatively different from looking through the university library--it has qualities of interaction and of testing of ideas that are not possible with a book.

Competition and collaboration

131. Because technology-based learning and distance education are both growth industries, they offer opportunities for collaboration among industry, business, educational institutions and governments. Every member country of OECD finds itself with a challenge to adapt to the new global market place, and

education and training are often cited as important components of the response. Clearly, new institutions with all their accompanying infrastructure cannot be (nor should they be) built to respond to these needs. It has been the traditional role of post-secondary education to prepare people to work and hopefully prosper in their country. It has been said earlier in this report, however, that this dominance and the public service basis of education are being challenged, but that the institutions have, up to now, been slow to respond.

132. Much post-secondary distance education in North America is supported by patrons, who. tend to be corporations supporting a training programme that addresses deficiencies in the local labour pool. Some provide equipment, teachers, tutors, subject expertise and financial aid. In the future, the trend may be that the educational institution provides the training directly to the workplace for its own employees rather than to members of the general public who might then be hired by the company. This challenges some of the concepts of public education but can bring the educational institution the necessary additional revenue and resources.

133. Governments all over the world are desperately trying to cut public expenditures, including those for education and training. And companies are looking for good and cheap solutions to the labour and skill problems that they are facing. Traditional educational institutions--from universities to colleges to technical schools to secondary and primary education--must come to terms with the reality that the period when they had the local or regional monopoly for education has to an end. They need to adapt their organisation and social structure to meet the emerging competition in order to ensure their survival in a new role in the next century.

134. The National Technological University--which has been offering graduate engineering courses in North America via satellite co-operating with engineering and technology departments in numerous universities -- has become the fifth largest engineering school in the US. The difference here is that it is privately owned and operated and has been making substantial profits since very soon after its launch. Other entrepreneurial organisations, such as Whittle Communications, have launched a satellite news service to high schools that provides the schools with extensive equipment and makes a profit by adding two minutes of commercials as part of the newscast. With large government grants, Hughes Communications has been developing an educational service for US. schools that will be delivered on its satellites. Some parts of education, at all levels, are moving slowly into the private, for-profit, domain. The question of whether or not this will threaten the independence of institutions or bias the contents of education is an open one which should be investigated seriously.

135. The road towards privatisation has been with the collaboration of educational institutions who provide the courses, the credentials and some of the learner or administrative support, while the private firm may provide the technological access, the promotion, the student population (in the case of industry-specific training) and other aspects of learner and administrative support. With the continued importance of credentials, post-secondary institutions will have a crucial role to play in education, but the structures that support the provision of those credentials are changing.

136. The previous chapter mentioned the potential of the 500-channel environment, and many of the media giants are preparing for this eventuality as well as the convergence of telephone, video and computer technology. The new channels will require content, and this content can be as specialised and as narrowly focused as the thousands of specialist magazines that are produced around the globe. Although these massive networks are not being constructed to meet educational needs, the size of the potential educational market in terms of people and resources is too large to be ignored.

137. Billions of dollars are being invested in system upgrade and industry convergence. US West (the telephone company) has invested $2.5 billion in Time Warner (the programming and cable giant) in order to rebuild the Time Warner cable system to provide video-on-demand. American cable and telephone companies have helped build advanced networks that will bring telephone and cable service to British homes over a single line. According to *The Economist* again (p. 19), the leaders of these firms see a "dawning digital age in which the humble television will mutate into a two-way medium for a plethora of information and entertainment: movies on demand, video games, databases, educational programming, home shopping telephone services, telebanking, teleconferencing, even the complex simulations of 'virtual reality'." These are many of the same services and products that have been presented here as part of the future for technology in post-secondary education.

138. Of course, no one company, no matter how large, can bring this about on their own but governments have also been planning for the information highway that moves data, video and voice with equal speed and ease. The US. and Canadian versions are networks of networks, combining public and private enterprise, that will start with the scientific and research communities but will eventually extend to the home and the individual. Singapore has plans for a fibre-optic network to reach every building in the central business core by 1995. Japan is constructing a network to link research computers and databases despite software and application problems. Europe is faced with a greater challenge because of the national telecommunications monopolies and the consequent differing systems and the costs of cross-border networking links. However there is a European Community project, RACE (R & D in Advanced Communications for Europe), that is responsible for drawing up the blueprint for an integrated, high-capacity communications system.

139. The assumption is not that these companies have any intention of highjacking post-secondary education and bypassing the institutions, since they are essential to the provision of quality, credible content for these networks. But this content will not look like that which the universities and colleges currently produce. It will be interactive, multimedia information and guidance provided by a content and teaching expert who may be remote in time and place from the students and may only form part of metacourses that consider knowledge and what needs to be learned in completely new ways instead of lectures and assignments, with instructor-centred education backed up by the rules and traditions of an institution.

140. Businesses are investing billions in new technological delivery systems and the programming for them. Government and industry are likewise investing billions in educational systems that many are finding lacking, especially when faced with the economic and social realities of our era. Educational institutions are caught between the two forces and have an exciting opportunity to recreate themselves. This will not happen tomorrow and there are many stages between today's reality and a world that is more literate and more open in its attitudes toward technology. Post-secondary educational institutions still have the time to form the partnerships and make the changes that will ensure that they are as central in the 21st century as they have been in the 20th century.

Chapter 3

How Do We Get There?

"If you don't know where you are going, any road will do."
The White Rabbit, *Alice in Wonderland* by Lewis Carroll

A vision of education

141. Earlier chapters of this report have shown that a richly interconnected and highly leveraged network of computing resources, tools and information resources that provide students and teaching staff with unprecedented access across disciplinary, institutional and national boundaries is emerging through the use of the information technologies. The evolving national and international network infrastructure allows access by students and teachers to each other and to alternate centres of expertise. The implications for education could be enormous. Some commentators see the impact of technology on education being as important a watershed as the invention of writing or the printing press. One can point to a number of stages in the history of education, which has developed from the verbal transmission of knowledge in ancient times, through the use of writing to transmit information in medieval times, to the printed word in modern times. We now appear to be entering the "information age", which is characterised by the electronic transmission of information.

142. However, before we are carried away by the technology, it is as well, like Alice, to know where we wish to go. A shared vision of what we want education and training to be in the 21st century is therefore extremely important. The vision should take into account the potential of technology but should not be driven solely by what is possible technologically. The question is not how to use technology and, in so doing, somehow improve or even transform education but, rather, how educational institutions can exploit technology to provide the most effective learning, most efficiently delivered, and consistent with the budgets available in order to meet the challenges highlighted in the introduction to this report. Therefore, planning and controlling are more necessary than ever.

Trends

143. Some changes in education have already started to happen because of the impact of technology. Many others will take a number of years to have their full effect. Among the trends in the use of technology in teaching and learning, the following can be identified:

Acceptance of personal computers

144. There has been a very rapid acceptance and diffusion of personal computers and workstations in all areas of education. This acceptance can be expected to continue to grow. There will also be an increase in demand for ongoing investments in the bandwidth capacity of data communications to cater for access to very large datasets. Similarly, developments in scientific visualisation, on-line transport of radiological images, digital photography and videography, and on-line distribution of library holdings as character or image records will inevitably drive ongoing capacity investments and will increase dramatically the demand for network connections.

145. However, there is little evidence as yet that the "paperless" environment is in sight. Institutions continue to consume vast quantities of paper in order to disseminate information, even that of a largely ephemeral nature. Strategies and policies tend nevertheless to move institutions increasingly from the print to the electronic medium as a means of sharing rapidly changing information.

Proliferation of computer-based materials

146. The increased teaching staff access to easy-to-use and relatively inexpensive computing technology has made possible a proliferation of computer-based instructional material (particularly in the United States and the United Kingdom). Much of this development has been in the physical sciences, mathematics and engineering. Exciting work in computer-based instruction is also emerging across a broad curricular base, including language training, medicine, writing, literary analysis and the social sciences. Examples have been seen in Chapter 1 of this report.

Challenge of heterogeneous technologies

147. At the same time as the rapid acceptance and diffusion of personal computers and workstations have empowered teaching staff to develop courseware, the lack of standards and consistency and the problems of interoperability between different brands and operating systems have limited the widespread adoption of such courseware and have increased the number of technological islands. At the lowest level of communicating by e-mail, for example, there are no accepted standards for the transmission of formatted documents, with the result that even on the same campus, teaching staff have difficulty sending each other anything more than rudimentary text documents.

148. That same lack of standards and consistency is at least partially brought about by the continuing and constant emergence of new or enhanced technologies and exacerbated in many educational institutions through the exercise of academic freedom. The result is an increasingly complex and technologically heterogeneous academic computing environment. This in turn creates a continuing challenge to information technology executives to stitch it together in an apparently homogeneous environment, at least as far as teaching staff and students are concerned. Support of such environments, training in their use and the transfer of courseware developed on one technological platform to another in such environments continue to constrain progress in propagating instructional technology.

Focus on information resources

149. As network connectivity, capacity and reliability improve and increase access to rich sources of all types of information used in support of teaching and learning, the attention of teaching staff and educational institutions has become focused on the information resources themselves rather than on how

or where those resources are held. This new focus on the possible realisation of the ideal of information being available -- anything, anytime, anywhere -- by means of the electronic library responds to pressures such as:

i) the seemingly insurmountable financial pressures on library acquisitions brought about by the exponential growth in the volume of published work and the contracting budgets of libraries;

ii) the deterioration of institutional library collections printed on acidic paper stock;

iii) new open learning opportunities made possible by the new information technologies;

iv) the simple desire of teaching staff to have access to the sources of information on their desks and not just on the shelves of their institutional libraries;

v) the growth in the availability of national and international data sources over the network.

Towards an agenda

150. Elements of an emerging agenda to fully integrate information technology into post-secondary education can be considered at four levels, namely: governments, institutions, teaching staff and students. How should they cope with the demands and challenges placed upon them by a vision of the future which includes some or all of the following features?

i) All students will need to become computer literate as well as literate and numerate, that is, able to handle current information technology at a level appropriate to their discipline and be equipped to continue their development with it into the future. All students will make use of IT in their courses. Technology will contribute both to the methods of assessment as well as entering into the curricula and pedagogy of many subjects.

ii) In order to achieve this objective, students and teaching staff should have ready access at home, on campus or at their place of work to workstations and access to the network. There will be a rapid growth in the availability to staff and students of electronic information services such as the electronic provision of the full text of books and journals. Collections of software for use in teaching, including computer-based learning and multimedia materials incorporating audio and video as well as computer-generated graphics and text, should become accessible from anywhere on the network.

iii) The information technologies consequently appear to open up opportunities for electronic access to institutions and for the development of open learning institutions and agencies. Institutions may not have to be rooted in time and place. They could be accessible electronically from anywhere and available at all times. Institutions could consequently be a mix of physical campus and remote-access points, thus meeting the needs of groups whose family or work commitments prevent them from attending a particular place at a specific time.

151. Firstly, what role can governments play in fostering the development of the use of information technologies? Secondly, how should institutions react to the challenges of the potential of the technologies? What strategies should they adopt to make the vision proposed here happen? Thirdly, what will be the

impact on the teaching staff? How do they have to change? What is needed to encourage them to change and to adopt the new technologies in their teaching? And fourthly, what needs to be done for students and what do students need to do?

152. Although these four areas will now be treated in that order, that is, in an apparently top-down sequence, it should be stressed that the *most important of them and the one to which all the others* contribute directly or indirectly is the impact on students--the users or clients of the educational systems.

The role of governments

153. Governments need to take an approach to the planning and development of educational communications which includes all sectors of education and not just post-secondary institutions, since the same advantages and benefits can be obtained by all sectors of education. It is clear, for example, that the more networks are shared, the greater the economies of scale are possible.

154. Governments, in consultation with carriers and educational institutions, need to develop policies for educational applications of telecommunications technologies which provide equity of access, common standards and a unified network strategy including all telecommunications services (voice, data, fax, video, etc.), together with interconnections between institutions and with the external world, for example, Internet. A unified network strategy needs to be accompanied by a detailed analysis of teaching and administrative applications required by institutions in order to determine likely traffic volumes, before appropriate technological decisions can be made. Continued emphasis on and investment in the information and communications technology infrastructure is required.

155. In a number of countries, consideration is being given to expanding the networks originally set up to serve the academic community into national networks serving not just the universities but also the K-12 schools, technical and further education and adult and continuing education. Foremost among these is the United States, where access to the Internet and a National Education and Research Network (NREN) is being expanded to connect university campuses, community college and K-12 schools to a high-speed communications network providing a broad range of information resources. In Canada, the development of a national network is seen as being of national importance equal to that of other major projects such as the Canadian Pacific Railway which helped shape the development of the nation in the past. In Australia, an expansion of AARNet into a national education network could be seen as being in accord with many of the Commonwealth Government's education initiatives in recent years. In France, decisions in that area were announced by the Prime Minister in early 1994.

156. Such developments could have the following advantages:

- -- more efficient use of the human and educational resources of the country;
- -- improvements in the country's skills and competencies;
- -- improvements in the community's literacy in computing, networking and information;
- -- closer working relations between the various sectors of education to the benefit of the community as a whole;

-- improvements in the provision of library and information services.

157. There is a need for national approaches to the establishment of software and communications standards for education and training, the development of critical and innovative software packages and curriculum design, and the collection of information resources in a standardised format and the making of them available to educational centres through both conventional and advanced communication networks.

Research and development in the cognitive sciences

158. Next-generation information technologies informed by cognitive science techniques and theories may create a new world of diverse human interfaces that will make technology applications approachable and usable by many more people. We know that individual differences affect the rate and manner in which people accept computer technology. In the past, because of limitations in computing power, each individual had a limited choice of ways to interact with computers. With the dramatic increase in processing and speed of affordable personal computers, interfaces can be designed and accommodated to the vast array of individual differences. Next-generation interfaces will also be simpler to use. Because of more power, they will take much of the demand for doing repetitive syntactic tasks like typing and various forms of symbolic programming off the shoulders of the users.

159. A constraining factor is the lack of co-ordinating strategies to enhance the diffusion of courseware within academic disciplines and across institutions. In this respect, the work being done by the Computers in Teaching Initiative Centres in the United Kingdom is very significant. By means of this project, 20 CTI subject centres have been established. Each centre has responsibility for a different discipline so that between them they cover most subjects taught at the undergraduate level. Their mission is "to enhance the quality of learning and increase the effectiveness of teaching in all subjects within the United Kingdom university sector through the application of information technology". Each centre:

-- acts as a focus for gathering and disseminating information about the use of computers in teaching within its particular discipline area;

-- acts as a catalyst in encouraging the use of computers in teaching throughout the university community;

-- assists the development of improved methods of computer-based teaching.

160. Similar centres, mutatis mutandis, have been established in Sweden and are planned in Australia.

The role of institutions

161. How should educational institutions meet the challenges presented by information technologies, in particular with respect to teaching and learning? In the first place, the use of technology must be seen in the widest sense and in the context of the overall goals of the institution. There is consequently a need to plan strategically for technology. In the second place, how do institutions go about infusing IT into its teaching, and what are some of the issues involved in doing this?

Strategic planning for information technology

162. Careful definition and planning of the different educational purposes of physical and electronic access and of the use of the new information technologies are required by institutions. Therefore, as an integral part of their overall strategic planning, institutions should invest time and effort in developing an information technology strategic plan. Such a plan should be a guide to the institution in making strategic uses of the information technologies in its teaching, research and administrative activities. It should try to find answers to a number of questions. How can the institution make the most efficient and effective use of information technology in order to achieve its educational mission? How should it plan for its use of the information technologies? What directions should it take? What issues are involved? What equipment is needed? What software is required? How should computers be networked? What are the needs of staff? Of students? What are the resource implications, in the short, medium and long term? In short, how can the institution apply information technology in a cost-effective manner to support teaching, research and administration to enable the institution to achieve its goals?

163. It is beyond the scope of this chapter to discuss in great depth the issues involved in planning for IT and the reader is therefore referred to the literature on the subject, in particular to the many publications on the subject by the CAUSE organisation, which makes available in print or on the network a considerable number of plans. Some of the more important issues to be taken account of in developing such a plan are the following, which have been found to be significant from experience especially in the United States and Australia.

164. Information technology has to be seen as an important and integral component in the functioning and essence of the institution in all its aspects and not just as an operating tool. An IT strategic plan is therefore not just about the use of IT in teaching and learning, but about its use also in the administration of the institution, in its research activities and in its information services.

165. It is important to achieve the commitment of the institution to the information technology plan. Various strategies can be used to achieve this. For example, at Curtin University in Australia, the first stage in the development of the plan was the preparation of a "green paper" in order to provide the framework for informed discussion on the future directions of the use of the information technologies. The document was distributed to the University community at large and formed the basis of discussion in a number of open forums. The second stage of the development of the plan was the gathering of views and statements of requirements from the university community and their consideration by working parties drawn from a wide cross-section of the university. In the third stage, the Information Technology Strategic Plan was developed for formal presentation to the university through its committee structure including the university council. In this way, the university as a whole has been involved in the formulation and implementation of the recommendations of the plan. In addition, a new committee structure for information technology and systems was introduced in late 1992 involving the senior management of the university.

166. A fundamental issue is how change is effected in institutions with regard to the use of IT . Information technology does not happen without a very strong commitment on the part of the institution and the emergence of a champion of technology. This might be through the strong direction of the chief executive officer (it certainly does not happen without the strong support of the same); it might be through the conscious decision of the whole institution giving its assent to a commitment to IT. Whatever way the commitment is arrived at, it certainly does not happen without somebody in charge of driving the project.

167. It is important that the IT plan is seen not one which is immutably set in stone but as a plan which will evolve over the next several years, which will be modified in the light of experience and as the technology develops. Typically, an IT strategic plan addresses issues such as the uses to which information technology in its various forms is to be put, the infrastructure required to make those uses possible including the institution's network, hardware and software facilities, the needs of staff and students, for example for training and for support and assistance when necessary.

168. The strategic plan is basically a vision document which identifies the various options or strategic uses of information technology which are available and the aims and directions in which the institution can move. A full-scale plan always implies a considerable financial investment by an institution. Very few, if any, have adequate financial resources available to them to implement their whole plan immediately. In addition, priorities have to be set for the immediate future and for the longer term to accord with the institution's present and anticipated future situation. Therefore, a number of criteria must be taken into account, including, for example:

i) above all, and summing up all the other criteria, the extent to which the strategic use of technology contributes to the institution achieving its goals as established in its overall strategic plan;

ii) the extent to which the particular strategic use of technology contributes to the institution's priority areas; for example, it might be to provide the infrastructure needed to meet the anticipated growth in a particular discipline or extension of the campus network to facilitate research;

iii) the extent to which the strategic use contributes to the more effective and efficient operation of the institution; for example, the extent to which the implementation of an information systems plan improves the administrative systems of the institution;

iv) the extent to which the strategic use is an emerging, immature or innovative area on which it is appropriate to place particular emphasis and support for longer-term gains; for example, the use of computer-managed learning, computer-based learning, multimedia, videoconferencing;

v) the extent to which the strategic use, if implemented, contributes to meeting the expectations of students coming to the institution; for example, the level of student facilities;

vi) the extent to which the strategic use is an infrastructure that must be integrated across the Institution if it is to come to terms with the information age; for example, the extension of the campus network;

vii) the size of the population, whether of staff or students, that will be affected by the implementation of the strategic use;

viii) the extent to which the institution community, through consultation and participation in the development of the plan which has taken place, has indicated preferences for the implementation of particular strategic uses;

ix) the extent and degree to which the institution or school is already well developed in its use of a particular strategic use and consequently accords that use a lower priority in its present state of development.

169. With these general guidelines in mind, each institution will naturally have to draw up its own list of criteria, determine its priorities and proceed accordingly.

170. A group of people who must never be forgotten in the successful development and implementation of a institution's technology plan are the information technology services staff. These are the people who make technology happen (or not happen) and are consequently absolutely critical to the success or failure of any technology plan.

Infusing information technology into teaching and learning

171. The infusion of information technology into the teaching/learning process presents opportunities and challenges for organisations. It is not easy. Some of the issues involved include the adequacy of student facilities and of the teaching staff, the support services needed, and the availability of suitable software.

172. With regard to the latter, there are basically two strategies: either develop new software or use courseware which has been developed elsewhere. The creation or development of local software is, however, limited by a combination of the uneven pedagogical literacy of teaching staff; the uneven computer literacy and preparedness of teaching staff and rewards for teaching staff that discount the time, effort and achievement involved in instructional innovation. Few institutions have the resources to develop independently the software that is needed and probably none would expect to. (How many, for example, currently develop all their own textbooks?) Chapter 1 has described some examples of collaborative development projects in a number of institutions. A useful strategy for most if not all institutions, therefore, is the adoption of software developed elsewhere.

173. Teaching staff need support services such as reference librarians, media specialists, instructional-systems developers, computing consultants and equipment technicians to assist them in gaining access to and effectively using information and instructional technology.

174. A strategy which has proved successful in resolving many of the issues related to the infusion of IT into teaching has been the establishment of centres or units at the institutional level specifically charged with:

- -- finding, adapting, developing and accepting pertinent applications software and courseware;
- -- providing local support to teaching staff;
- -- ensuring that students have access to the hardware and software they need.

The role of the teaching staff

175. The ultimate decision about whether to incorporate information technology into the teaching/learning process very often depends on the individual teaching staff and is made, often implicitly, on the basis of perceived trade-off between marginal increase in student learning and the perceived investment in time to learn to use the technology. Most teaching staff currently have no overriding reason

to make this investment, being caught up in other obligations such as research, the need to publish, presentations to professional societies and community service.

176. Investments in the use of the information technology in teaching and learning cannot be fully effective unless staff receive training and support. Many successful examples of creative teachers using computers and other learning technologies to enhance and enrich their teaching can be seen around the world. But these are exceptions and it does not occur unless four interrelated conditions are met:

i) training in the skills needed to work with technology;

ii) education that provides visions and understanding of state-of-the-art developments and applications;

iii) support for experimentation and innovation, and, perhaps most valuable of all;

iv) time for learning and practice.

Advances and use of new technology will intensify the need for continuing training for proper integration into the curriculum and, as more teachers become interested in using computers, application software and courseware, they will need computer skills if they want to develop instructional software themselves.

177. The training that is required is not just in the use of the hardware or even of specific software packages. It is rather of showing staff how they can use technology in their teaching in their own specific subject area. At Curtin University, for example, a number of short courses entitled Teaching Without Paper have been conducted for teaching staff, showing the ways and means of using technology, whether in the lecture theatre or the smaller classroom, of incorporating use of the network into their teaching and of identifying what software is available that might be suitable to their teaching. The impact on staff has been considerable. A very experienced teacher who had taught computing to students for a number of years said after the course: I thought I knew all about computers; I now realise I knew nothing!

178. Staff should be encouraged to experiment as broadly with teaching and learning as they do with research and to check whether an application of technology will improve student learning. Institutions and authorities should provide teaching staff with incentives and rewards for remaining technologically current in their own disciplines and integrating appropriate technology into their courses and related support services for students. In this respect the grants awarded by industry, government and associations are very significant.

179. Teaching staff need to be provided with an appropriately configured scholar's workstation located in their office which is linked to libraries, shared computing resources, knowledge bases, media centres and colleagues internally and externally via an integrated network of voice, data and video. Although the situation is improving, not all teachers have access to such facilities.

Meeting students' needs

180. The importance of information technology in today's society is unquestioned. Few students do not need to learn to use computers for the benefit of their own academic and professional activities. Information technology is revolutionising the ways in which knowledge is being collected, analysed, stored,

presented and transmitted. Students must be computer literate, that is, able to handle current information technology at a level appropriate to their discipline and be equipped to continue their development with it into the future. Institutions have to prepare their students for life in that society by incorporating into their curricula appropriate training in the technologies and providing access to technologically sophisticated classrooms, laboratories and learning centres that facilitate teaching and research supporting the teaching mission of institutions. Institutions which fail to do so will be left behind by those that do. This is one of the many, if not the biggest, challenges faced by all institutions.

181. In the past, the OECD has identified the lack of adequate hardware facilities as one of the factors inhibiting the more widespread use of the information technologies in teaching and learning and has estimated that an adequate ratio for high schools is one microcomputer per ten students, i.e. 30 minutes per student per day, or two and a half hours per week, and an ideal ratio of one microcomputer for every five students. The Office of Technology Assessment (OTA) of the Congress of the United States has estimated that the required ratio is 1:3.

182. The report of the United Kingdom Inter-University Committee on Computing has recommended a ratio of one workstation for every four students. In doing so, it is not recommending that this ratio should be applied across all subject areas. A model has been developed which is based on the classification of disciplines into seven subject categories and then the weighting of these categories according to the anticipated level of use in each of the three basic uses of computing in education, namely learning about computing, learning through computing, and learning with computing. Using this model, the following target ratios for 1996 are arrived at:

Subject area	target ratio
Medicine	1 to 8
Science	1 to 2
Engineering and technology	1 to 2
Mathematics (including computing)	1 to 2.5
Social sciences	1 to 4
Humanities	1 to 8
Education	1 to 8

183. The model is presented as a best estimate. It does not attempt to define the level or type of workstation required in each subject area, nor to take account of the profile of the particular institution or of the fact that there will be variations within each group of subjects.

184. A number of strategies could be used to achieve the target ratio. One is to require all students to have private access to a personal computer. There is, however, clear evidence that not all students can afford their own computers and there is consequently an equity issue in enforcing this strategy; secondly, whilst this might be appropriate for some types of students--for example computing and engineering, and some of the business and science students because their studies involve them in heavy use of computing--as big an issue is having access to all software that they might need to use. Some institutions have found that there is no need to require students to own personal computers, since as many as over 50 per cent of them do already have private access to a computer. For these and other reasons, some institutions have chosen

instead to adopt a laissez-faire policy of providing open-access facilities for students and not impose a requirement to purchase a computer.

185. As big a problem as providing access to hardware is that of software. Some software will be required by all students for the duration of their course and all students must expect to have to purchase, for example, a word processing system just as much as they would a pen, and computing students a programming language and a compiling system just as they would an approved textbook. Other software will be required to complete a particular assignment or topic, for example the use of a particular simulation or tutorial, in much the same way as students will require access to library books and journals. One solution is to provide access to such software on computers installed in a number of large computer-based study halls which are not dedicated to classroom use and are connected to a network with file servers holding the required software. This solution allows a considerable range of software to be available through controlled usage rather than trying to provide each student with copies of the software.

Concluding remarks

186. The vision is of a networked society with equal access to knowledge and information; communities and individuals in charge of their learning environments; government, educators and the private sector working in partnership; an education and training system delivering the skills and knowledge needed for a free and prosperous society in the 21st century.

187. Will this happen? When will it happen? Tough political decisions are required regarding access to and regulation of telecommunications networks, copyright law and investments in educational materials and communications. It needs a close examination of the purpose and function of educational institutions in the 21st century and of their use of electronic technologies to meet new educational needs. It needs enthusiasm and energy to seize the opportunities and meet the challenge.

General conclusions

188. In the past, each time a new medium was invented, predictions were made as to its revolutionary role in education. It was true for printing, then for radio as well as for the cinema and television. In fact, each time, the net result has effectively caused some changes in education, but fundamentally the structure has not changed, and we still have professors and students, classrooms and lectures, blackboards and homework, marks and examinations, etc. Each time, the new medium has been absorbed and digested and has finally become an "add-on" rather than a revolution.

189. For instance, the invention of printing (among other causes and in the long term--i.e. after three centuries) led to the necessity to teach everybody to read and write. However, even this major change was implemented without any significant change in the structure or methods of education simply by generalising the previous system through a little less learning-by-heart, a little less handwriting for the student, and some variations in the pedagogy due to the existence of the printed text.

190. Radio has been used world-wide for entertainment, but a number of public stations in all countries have offered cultural and educational broadcasts. On the whole, however, the role of radio in post-secondary education has remained marginal. The cinema, which was considered by some education experts at the end of the nineteenth century as potentially replacing most printed text (live pictures are more significant than text) has become the seventh art and has found, despite its potential, only modest applications in education prior to the advent of television.

191. Social and economic factors have strongly contributed over the last years to promote seriously the of use of modern information technology (television and networked computers) in post-secondary education.

192. An increasing number of teenagers tend to enter post-secondary education either because they consider that the status of student is preferable to unemployment or because they think that with a higher degree it is easier to find a job. Moreover, because technological progress is changing the workplace, the training of a unskilled workers and the retraining of skilled labour force has become a pressing demand from many companies and in many countries is a critical economic and political problem.

193. All this leads towards an increase in the number of students in post-secondary education, which is already growing beyond the capacities of established institutions, at a time when governments, because of the economic depression, have a tendency to decrease all budgets, including that for education. In addition, the new student population (either the unskilled or the skilled workforce to be retrained) has special needs regarding the time and place when they are available for education, as well as special requests regarding content and teaching methods which are different from those of students studying for a degree right after graduation.

194. There are reasons to believe that the problem can be solved, at least partly, by the use of information technology in the form of interactive television or, better (because it includes the advantages

of the television and has many more), networked multimedia personal computers. Moreover, various experiments have shown that information technology is sufficiently versatile to be adaptable to individual differences in learning styles, is asynchronous by definition (i.e. available 24 hours a day) but can be made synchronous if necessary and is, or will become, in the long range, less expensive than standard institutional education.

195. Television has long been used for instant (real-time) transmission of moving or still pictures (with sound) over distances from small (closed-circuit television) to large (satellite television) which is the very meaning of the word "television". For a number of years it has been possible to use it in "cinema mode" with a videocassette recorder (VCR) and video cassettes, with the added possibility of recording incoming live sequences for later replay. Both modes have and are being used in education. The first is mainly used for distance education, giving opportunities for learning to those who are unable to attend traditional institutions. In most cases, however, it is used as an add-on to print and other technologies to extend the learning potential. Interaction with a tutor and other students is often required, to avoid isolation, and can be added through the use of telephone links. The "cinema mode" is used for face-to-face as well as for distance learning to add visual information which is essential in many disciplines but, from the user's point of view, is no different from the cinema except for its ease of use which can even be increased by replacing the VCR by an interactive compact disk.

196. Wherever it has been used, television has greatly improved education (distance as well as face-to-face) but globally, with few exceptions, it has been used as an add-on to existing technologies and has had very little influence on the general content and structure of post-secondary education. The advent of the computer is pushing television to become digital, as it has already done with the telephone and sound recording, and the future will, without any doubt, see an increasing co-operation between digital television, digital text and data processing and digital telecommunication in the so-called "interactive multimedia station". Most experts believe that the "multimedia station" has great potential for teachers and students, mainly because of its high degree of interactivity, and its current place and role in educational processes, are being investigated in a number of countries.

197. For distance education, the personal multimedia computer linked to a network is not only interactive around the clock by its very nature (electronic mail and/or fax with tutors and instructors either by text or pictures or video clips or drawings or voice) but it also allows each user to access various sources of information as well as specialised discussion forums on different subjects which may be of interest to him. In that way, all students involved in the same course can communicate between themselves, share problems and solutions, and form a virtual classroom together while being in different places and at different times. This is something radically new in education, with consequences on the teaching/learning process which remain to be investigated seriously as to the type of pedagogical strategies it implies.

198. For face-to-face education, students sitting at a connected microcomputer (more and more students will have their own portable one) are at school wherever they may be as long as the central computer of their institution is accessible through the network. The school is everywhere where they take their computer and have access to a telephone outlet. Moreover, the computer becomes a personal assistant--keeping the agenda, reminding of things to do, allowing the sending (and receiving) of mail instantly anywhere and any time--by making the simulation of anything, the testing ideas and hypotheses, or the consulting of documents, maps and statistics, an easily achieved goal This again is radically new in education because, up to now, not only have students not had an assistant doing standard work in his or her place, but all students have had in fact to learn to be their own assistant. While a part of the student's task has been to learn to find a method to solve a problem, the other task of learning all the details of the

method to be able to apply it without error as been taken over by the computer as "assistant". This will lead to a radical change in how students learn, understand, memorise and apply their knowledge. What has to be changed in the teaching/learning process; in the content of what is taught? Which pedagogical strategies are to be used in this new environment? Much work remains to be done in cognitive psychology to solve these problems.

199. Broadly speaking, education up to now has been teaching about the world as it is, offering students a certain number of skills necessary to make a living in society. However, the rapid progress made in technology is changing this world and its society and initial learning has become more and more rapidly obsolete. The net outcome, which has already begun, is that the workforce of a country needs to be retrained continually and, as progress continues in the future, this retraining will be more and more often necessary. The great number of people involved in this process makes the situation completely unrealistic for the future because no country in the world will have the resources to pay for having one half of the country teaching the other half.

200. Thus, education is facing a new and very difficult problem: what can be done to avoid the fast obsolescence of knowledge? One possible answer is known: teach, in each discipline, more fundamentals and more theory, and leave the learning of facts and figures to the student. This has been impossible up to now because teaching facts and figures has taken almost all of the available learning time. However, it becomes possible with IT because the time needed to handle facts and figures decreases by many orders of magnitude when a computer is used which, therefore, leaves more time for the study of theoretical aspects. Theories, which now become only slowly obsolete, are more and more indispensable for a critical appraisal of the results given by a computer.

201. The problem of the role of information technology in face-to-face education is not any easier to solve than that of its role in distance education; the more so that there are in both cases social, economic and political issues which do not simplify the problems. One of the first issues is who will pay for the hardware, the software, the cost of telecommunications, the networking and the people in charge of the daily working and maintenance of the local network? The government? The institution? The students (i.e. their parents)? These are political issues. What advantages will rich students have if they can afford more powerful computers than poorer classmates? Can this be avoided through a well-designed curriculum where this kind of advantage is minimised?

202. Institutional education is sometimes said to be too expensive because of its bureaucracy, etc. and that by privatising it costs would decrease and even make it profitable. Whereas co-operation on certain points can be profitable to both parties (see the Whittle experiment later in this report), to privatise completely implies higher fees, which would mean limited access or second-class education for the poorer student. These are social and economic issues which will sooner or later become political issues.

203. Finally, it should be kept in mind that it does not make sense to speak about the role of technology in education without addressing the problem of teacher training. It has been said repeatedly that, compared to past innovations, the introduction of technology in education represents a quantum leap but that nothing will happen if teachers are not properly trained. This means being trained to make the best pedagogical use of technology and not just being taught the technicalities of the devices, which has mostly been the case up to now. In turn, this implies that the training has necessarily to be done discipline by discipline and by trainers who are themselves teachers who have used IT in their teaching. Information technology in history is different from technology in physics or in natural sciences or in music, so the training should be different. This is an economic issue because training a large number of people in small

groups can become extremely costly. When preparing a plan to introduce technology in an institution, training of the teaching staff should therefore be carefully evaluated because it can be of the same order of magnitude as the hardware or software and yet is the essential investment. Information technology in education can be the best or the worst thing in the world, depending on how it is used. The quality of education at an institution, even with or perhaps because of information technology, is more than ever a direct function of the quality and the competence, and therefore the training, of the teaching staff.

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